Volume 3
Number 1
June 1978

entomon

PUBLISHED BY

THE ASSOCIATION FOR ADVANCEMENT OF ENTOMOLOGY

DEPARTMENT OF ZOOLOGY, UNIVERSITY OF KERALA, KARIAVATTOM,

TRIVANDRUM, INDIA 695581

ENTOMON

Entomon is a half-yearly journal of the Association for Advancement of Entomology issued in June and December, devoted to publication of research work on various aspects of insects and other land arthropods.

Address MS and all editorial correspondence to the Managing Editor, *Entomon*, Department of Zoology, University of Kerala, Kariavattom, Trivandrum, India 695581.

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ENTOMON

Volume 3 **Number 1** **1978**

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AERODYNAMIC PARAMETERS OF *CHRYSOCORIS PURPUREUS* (WESTW.), (PENTATOMIDAE: HETEROPTERA)

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(*Received 30 December 1977*)

The aerodynamic characteristics of male and female bugs of *Chrysocoris purpureus* (WESTW.) are different. No good correlation seems to exist between wing loading and aspect ratio. The average wingbeat frequency values of males and females are the same (94 Hz). Induced power in hovering state is also calculated. Resilin is present at the wing base and facilitates high frequency movements. The functional anatomy of the pterothoracic muscles has been considered.

(*Key words:* **aerodynamic parameters, *Chrysocoris purpureus*, Pentatomid**)

INTRODUCTION

Insect flight differs from those of birds and bats anatomically, and physiologically and has a different phylogeny. WEIS-FOGH & JENSEN (1956) have extensively studied the biology and physics of locust flight; PRINGLE (1968, 1974) has reviewed the aerodynamics and kinematics of insect wing motion. NEVILLE (1965) has discussed the energy and economy in insect flight. VOGEL (1966) has studied the flight performance in *Drosophila*. PURANIK and coworkers (1973, 1976, 1977) have developed experimental techniques for the determination of wingbeat frequency of insects, analysed the flight sound of *Tessaratoma javanica* by Fourier synthesis and also developed a theory for determining the 'wingbeat frequency of a flier in hovering state' on the basis of mass flow of air. In the present communication, a systematic study has been undertaken about the aerodynamic characteristics of the pentatomid bug *Chrysocoris purpureus* (WESTW.).

MATERIALS AND METHODS

Adult bugs collected locally were maintained in the laboratory for 5–7 days on host plant *Croton sparsiflorus* MOR. (Fam: Euphorbiaceae) at room temperature during August to November, 1976 and 1977. The mass of the insect was determined with a sensitive balance. The magnified wing area was traced on a paper and measured by using a planimeter and subsequently the actual values were calculated. The flight frequency in 'tethered state' was measured with a stroboscope (Radart).

The aerodynamic parameters determined are wing loading (g/cm^2), aspect ratio, flight frequency (Hz) and induced power (μ cal/sec) in the hovering state. The induced power calculations were made by using the formula suggested by PENNYCUICK (1971). Reynolds number and related parameters were calculated. Least square fit was applied for determining the 'critical mass' from the graph of mass versus induced power in hovering state. Observations were also made on the pterothoracic musculature

RESULTS AND DISCUSSION

Table 1 shows the basic aerodynamic parameters of 50 male and 50 female insects. The wing loading is of the order of 0.10 g/cm^2 thereby indicating a relatively high wing

TABLE 1. Basic aerodynamic parameters of *C. purpureus*.

	Male		Female	
	Range	Mean ± SD	Range	Mean ± SD
1. Body mass (g)	0.125—0.205	0.168±0.018	0.133—0.233	0.179±0.024
2. Wing length (cm)	1.15 —1.27	1.21 ±0.04	1.11 —1.29	1.23 ±0.03
3. Wing span (cm)	2.99 —3.39	3.17 ±0.09	3.03 —3.44	3.21 ±0.08
4. Wing area (two wings) (cm^2)	1.407—1.788	1.616±0.129	1.347—1.995	1.666±0.139
5. Wing breadth (effective) (cm)	0.61 —0.75	0.66 ±0.02	0.61 —0.79	0.66 ±0.02
6. Wing loading (g/cm^2)	0.08 —0.129	0.105±0.019	0.078—0.143	0.108±0.017
7. Aspect ratio	1.66 —2.07	1.83 ±0.08	1.58 —2.23	1.83 ±0.13
8. Mass/(2 wing length)^2	0.021—0.033	0.028±0.001	0.022—0.039	0.030±0.001
9. Wingbeat frequency (Hz)	76—113	94±9	71—106	94±10
10. Induced power (μcal/sec)	241—475	374±77	259—559	403±79

area in relation to mass. The wing loading is low as compared to bats and birds thus suggesting the relative aerodynamic efficiency of the flier. The plot of mass versus wing loading (Fig. 1) appears linear with equal percentage of scattering along the curve and the regression equation is

$$Y = (0.62)\ X \quad \ldots \quad \ldots \quad (1)$$

The fliers have simple triangular wings; hence in this study the aspect ratio was taken as the ratio of wing length to wing breadth (NEVILLE, 1965). These values range from 1.66 to 2.07 for males and from 1.58 to 2.23 for females. No good correlation seems

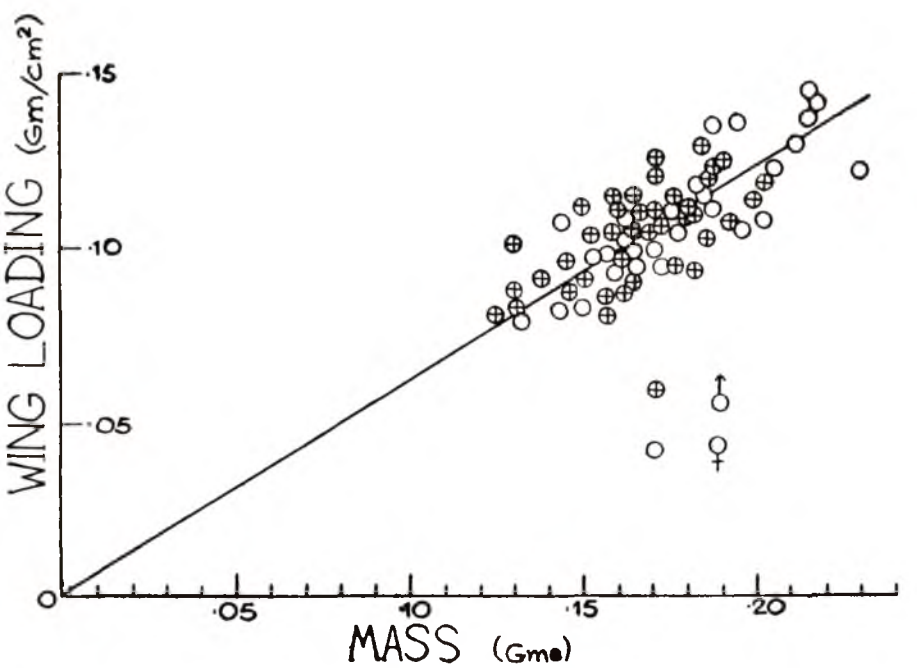


Fig. 1. Graph between mass and wing loading.

to exist between the wing loading and aspect ratio (see Table). Further calculations show that the values of mass / wing span^2 are also variable (0.013 to 0.022). But in bats and birds a good correlation was shown to exist between the aspect ratio and wing loading (PURANIK *et al.*, 1976; ARAVIND *et al.*, 1978a,b).

The observed minimum and maximum values of wingbeat frequencies are 76 and 113 respectively and the insect has asynchronous muscles. Certain big bugs (Belostomatidae) also possess asynchronous muscles and generate low wingbeat frequency at about 50 Hz (see PRINGLE, 1976) whereas in *Tessaratoma javanica* the wingbeat frequency ranges from 60 to 80 Hz (PURANIK *et al.*, 1977). It can be surmised that the myogenic big bugs have lower wingbeat frequencies as compared to Diptera and Hymenoptera. However, resonance frequency of the thorax wing system in *C. purpureus* is higher as compared to belostomatid bugs and *T. javanica*.

The graph plotted between the wing loading and wingbeat frequency (Fig. 2) hows a fairly good correlation between wing oading and wingbeat frequency. The regression equation is

$$Y' = (892.3)\, X' \quad \ldots \quad \ldots \quad (2)$$

Vogel's index computed in the present study is 30 and the contribution of this index in aerodynamics can be decided by further study of the kinematics of wing motion.

The study of the Table shows that the induced power is variable from 241μ to 559μ cal / sec, it increases with increasing mass and the ratio of female to male is 1.08. A graph is plotted between mass and induced power in hovering state (Fig. 3) and the regression equation is

$$Y'' = 3419.25\, X'' - 204.81 \quad \ldots \quad \ldots \quad (3)$$

The value of the 'critical mass' so obtained is 60 mg. The critical mass concept although of theoretical interest needs further experimental evidence from the studies on last

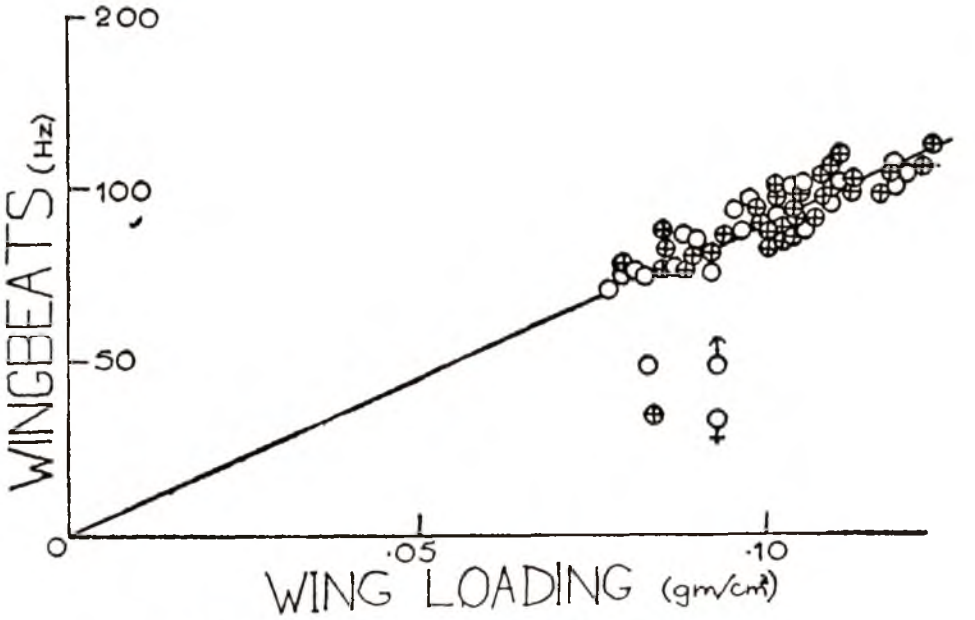
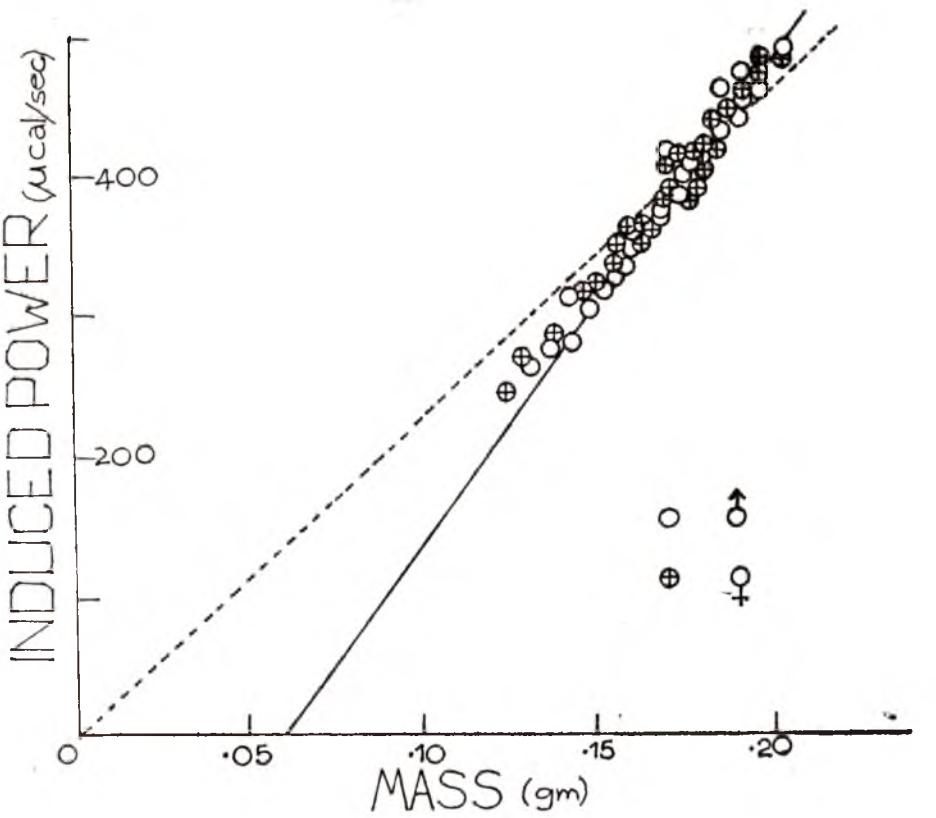


Fig. 2. Graph between wing loadnig and wingbeat frequency.



F g. 3. Graph between mass and induced power in hovering state.

nymphal instars and 1–3 days old imago flight muscles. The induced power calculations appear significant since they are related to the oxygen consumption and energy metabolism of flight and hovering in nature is practised by some small insects and medium sized birds. The flight muscles of insects are of highly oxidative type (CHARI, 1970, 1973).

The cost of energy transport (the energy needed to move a unit mass of animal a unit distance) as identified from the mass of the insects by using the standard chart (TUCKER, 1969) is of the order of 7–10 cal/gkm. It has been observed that the tethered flight of *C. purpureus* lasts for 45 to 50 minutes in the laboratory. The a mplitude of wingbeat in tethered flight is 110° ± 5° and the ideal value for hovering is 120°. The velocity of free horizontal flight as observed in nature is variable from 100 to 120 cm/sec. Reynolds number so calculated with body length as reference would be of the magnitude 1000 ± 50 and the lift appears to be the dominant force.

Observations on the anatomy of the pterothoracic segments show that these two segments have only one pair of dorsal longitudinal muscles, one pair of vertical muscles and one pair of oblique muscles (all indirect muscles) having rich tracheal supply and are responsible for the down and up movements of the wings. Large air sacs are associated with these muscles. The meso- and metathoracic wings are firmly coupled during flight and the wing tip

traces a figure of 8. It has been observed that *C. purpureus* hovers in nature since it possesses oblique dorsal muscles. This is in agreement with PRINGLE'S (1974) observations. The basalar, subalar and the third axillary muscles (direct muscles) are well developed in each segment. However, the short pleurosternal muscle with its long apophysis is confined to mesothorax and appears to contribute to lateral elastic stiffness of the thorax during flight. The elastomere protein which has been found positive for resilin test (ANDERSON & WEIS-FOGH 1964) in the present investigation is rather well developed at the mesothoracic wing base and facilitates high frequency movements. All the pterothoracic muscles are innervated by the fused compound thoracic ganglion. Mesothoracic musculature is relatively well developed as compared to metathorax. The 'flight machinery' is complex and how the contraction of each type of muscle contributes to the kinematics of the wing motion leading to the development of lift and thrust by the flight surface remains to be elucidated.

Acknowledgements:- This work is supported by a special grant for research in Biophysics from the Kakatiya University, Warangal, A. P. We are grateful to Prof. K. VENKATA RAMIAH, Vice-Chancellor, Kakatiya University, for the criticism of the manuscript and for the constant encouragement. One of us (AAB) thanks the UGC, New Delhi, for the award of a fellowship.

REFERENCES

ARAVIND BABU, A., V. VENKATA CHALAPATHI & N. CHARI (1978a) Aerodynamic parameters, flight energetics and strip analysis of the wing of *Acridotherus tristis*. *Indian J. exp. Biol.*, **16:**

ARAVIND BABU, A., N. CHARI, A. KISTA REDDY & P. VENKAT REDDY (1978b) Observations on the flight parameters, energetics and moment of inertia of the wing in jungle bush quail, *Perdicula asiatica*. *Comp. Physiol. Ecol.*, (in press).

ANDERSON, S. O. & T. WEIS-FOGH (1964) Resilin, 1-66, *in: Advances in Insect Physiology*, Vol. 2 (ed. BEAMENT, J. W. L., J. E. TREHERNE & V. B. WIGGLESWORTH), Academic Press, New York & London.

CHARI, N. (1970) Metabolic differentiation of functionally different muscles of some insects and other invertebrates. C. Sc. thesis, Czech. Acad. Sci., Praha. Czechoslovakia.

CHARI, N., A. BASS & I. HAJEK (1973) Biochemical differences of fast and slow coxal muscles of male and female *Periplaneta americana*. *Curr. Sci.*, **42** : 541-542

NEVILLE, A. C. (1965) Energy and economy in insect flight. *Sci. Prog. Lond.*, **53** : 203-219.

PENNYCUICK, C. J. (1975) Mechanics of flight, 1-65, *in : Avian Biology*, Vol. **5** (ed. FARNER, D. S. & J. R. KING), Academic Press, New York & London.

PRINGLE, J. W. S. (1968) Comparative physiology of the flight motor, 163-228, *in : Advances in Insect Physiology* Vol. **5,** (ed. BEAMENT, J. W. L., J. E. TREHERNE, & V. B. WIGGLESWORTH), Academic Press, New York & London.

PRINGLE, J. W. S. (1974) Locomotion - Flight, 433-476, *in : The Physiology of Insecta*, Vol. **3,** 2nd ed. (ed. ROCKSTEIN, M.), Academic Press, New York & London.

PRINGLE, J. W. S. (1976) The muscle and sense organs involved in insect flight, 3-15, *in : Insect Flight* (ed. RAINEY R. C.), Blakwell Scientific Publication, Oxford & London.

PURANIK, P. G., N. CHARI & R. D. SUKHDEV (1973) New methods for measuring lift and wing beat frequency. *Indian J. exp. Biol.*, **11** : 579-580.

PURANIK, P. G. & ADEEL AHMED (1976) Fourier analysis of the flight sound and pressure pattern of the wings of *Tessaratoma javanica*. *Indian J. exp. Biol.*, **14** : 279-281.

PURANIK, P.G., G. GOPALAKRISHNA, ADEEL AHMED & N. CHARI (1977) Wingbeat frequency of a flier-mass flow theory. *Proc. Indian Acad. Sci.*, **85B:** 327-339.

PURANIK, P. G., G. GOPALAKRISHNA & N. CHARI (1976) Aerodynamic parameters of a short nosed fruit bat *Cynopterus marginatus*. *Proc. Indian Acad. Sci.*, **83B** : 160–165.

TUCKER, V. A. (1969) The energetics of bird flight. *Sci. Amer.*, **220** : 70–78.

VOGEL, S. (1966) Flight in *Drosophila*. I. Flight performance of tethered flies. *J. exp. Biol.*, **44** : 567–578.

WEIS-FOGH, T. & M. JENSEN (1965) Biology and physics of locust flight. I. Basic principles in insect flight. A critical review. *Phil. Trans. R. Soc.*, **239B** : 415–458.

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SENSITIVITY TO GAMMA RADIATION OF *CORCYRA CEPHALONICA* EGGS RELATED TO THEIR AGE

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Eggs of *Corcyra cephalonica* 0-24, 24-48, 48-72 and 72-96 hour old, were irradiated at different doses in a Co^{60} source. The radiosensitivity of the eggs was profoundly affected by the egg-age. About thirteen fold increase in the radiation dose was required to prevent egg hatch from most sensitive (0-24hr) to most resistant (72-96 hr) age. A dose of 3.85 krad inhibited 100% eclosion in 0-24 hr old eggs while this dose had no ill-effect at all on 72-96 hr old eggs as far as hatchability is concerned.

(*Key words:* **Gamma radiation, *Corcyra cephalonica*, age-related sensitivity**)

INTRODUCTION

Recently several reports have appeared concerning the effects of gamma radiations on the immature stages of a number of insects (PROVERBS & NEWTON, 1962; HOUGH, 1963; COGBURN *et al.*, 1966; VEREECKE & PELERENTS, 1969; EL SAYED & GRAVES, 1969; REICHLE, 1969; BROWER, 1972, 1974; GONEN & FISHBAIN, 1974). In most of these cases the eggs became more radiotolerant as they aged. Probably this susceptibility to radiation could be attributed to the changes that occur in the structure and function of some systems in insects with age and which modify the internal environment (CLARK & ROCKSTEIN, 1964).

The rice-moth, *Corcyra cephalonica* is one of the most serious pests of stored-grains and other food products in India. It is inconceivable to store rice or other food grains and nuts without the apprehension of *Corcyra* infestation. Before storing the food material, it is very difficult to detect the presence of eggs and young larvae. In order to eliminate this problem of inclusion of eggs and young larvae that escape the detection in the food-grains, one of the feasible ways is to irradiate the grains. It is, therefore, very essential to investigate the minimal radiation dose required to get rid of undetectable infestation. Also, as with age the eggs become more radiotolerant, there arises the necessity of a thorough investigation of the effective dosage and the radiosensitivity of the eggs of this insect pest. The present study is an attempt to fill these needs.

MATERIAL AND METHODS

Freshly emerged adults of rice-moth, *Corcyra cephalonica* STAINT. were collected from laboratory stock culture maintained on sorghum and 5% yeast at 30 ± 2° C and 70 ± 5% RH and were caged together in inverted wooden boxes provided with No 16 wire-mesh lids. They were allowed to mate and lay eggs only for 24 hr and were later discarded. The eggs that fell through the wire mesh were collected and separated in the groups of 100 eggs each. For the next lot of eggs, another group of fresh adults were taken and their eggs collected. The eggs were irradiated by gamma radiations from a Co^{60} source in Gamma cell type 220 which gave an average dose of ca 1540 rad/min at the time of exposure. Four replications of 100 eggs each were irradiated with each dose, ranging from 770 rad to 50.82 krad. In this way four sets of eggs belonging to 0–24 hr, 24–48 hr, 48–72 hr and 72–96 hr age groups were irradiated (it takes about 96 hours for the eggs to hatch). After the treatment, the eggs were allowed to develop normally and were observed

daily for the hatch. The hatchability of the larvae was worked out statistically.

All possible care was taken to calculate the right amount of dose depending on the geometry of the sample vials placement in the gamma cell. All the tubes containing eggs were put in a big container for exposure. Eggs requiring the minimum dose were taken out first and the one requiring higher, subsequently. In this way any anomaly in stipulated dose due to random nature of radioactive disintegration was hopefully avoided.

RESULTS

Fig. 1 shows the effect of gamma irradiation on the eclosion of *Corcyra* eggs of different ages and it clearly demonstrates that the age of the eggs at the time of irradiation had a profound influence on their hatchability. The mean percentage hatching of control eggs is 88.83 $\pm$ 0.58%. 0-24 hr old eggs were most radiosensitive. A dose of 3.08 krad of gamma irradiation is required to cause 95% decrease in viability in these eggs, while the same dose given to 24-48 hr old eggs produced 54.18% decrease in egg-hatch. Further, an irradiation of 3.85 krad was sufficient to prevent complete eclosion in 0-24 hr eggs but 3.6 fold increase in the dose was required to produce a similar effect in 24-48 hr old eggs. 72-96 hr old eggs exposed to this dose, however, showed no ill-effects and almost as many larvae hatched as from non-irradiated eggs. The radioresistance increased in these eggs and they required over 50 krad for a complete inhibition of egg-hatch. Although 48-72 hr and 72-96 hr

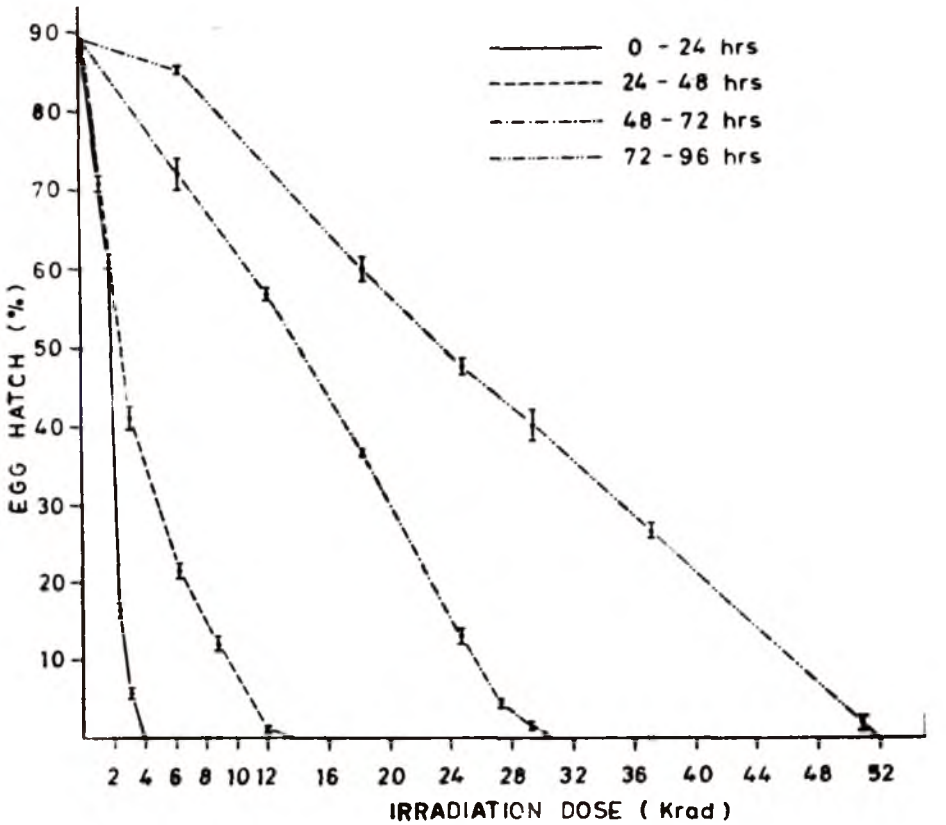

Fig. 1. Effect of gamma irradiation on eclosion of *Corcyra* eggs at different ages.

old eggs that exposed to low dosages, hatched reasonably well. The effect of radiation was reflected in the subsequent stages which showed a higher rate of mortality than in the control. The post-embryonic development was also retarded, the larvae were sluggish and less actively feeding. They had considerably longer larval and pupal durations. Further observations concerning the larval, pupal and adult mortality and the fecundity and sterility of the moths obtained from the eggs irradiated with low dosages are not considered in the present study.

DISCUSSION

Our study shows that the age of the eggs has a strong influence on egg-hatch due to irradiation. These results are in conformity with earlier studies on the eggs of *Ephestia* (GONEN & FISHBAIN, 1974), *Plodia* (BROWER, 1974), codling moth (PROVERBS & NEWTON, 1962; HOUGH, 1963), *Heliothis* (EL SAYED & GRAVES, 1969), *Gibbium* (BROWER, 1972), bagworm (REICHLE, 1969), *Tribolium* (VEREECKE & PELERENTS, 1969), *Drosophila* (HENSHAW & HENSHAW, 1933) and *Pediculus* (COLE *et al.*, 1959). The doses which produce lethal effect in 0-24 hr old eggs, have no significant visible effect on 72-96 hr old eggs. To bring this specific effect in 72-96 hr old eggs, about 13 times increase in the dosage is required ie., 0-24 hr old eggs are 13 times more radiosensitive than 72-96 hr old eggs. The increase of the radio-resistance in eggs with the increase of age is therefore, an important factor to be carefully considered whenever the radiation studies are undertaken.

Acknowledgements:— The authors wish to express their sincere thanks to Col. S.K. MAJUMDAR, Director, Institute of Nuclear Medicine and Allied Sciences, Delhi for permitting us to use the Gamma cell in his Institute. One of us (ATC) is thankful to the University Grants Commission for the award of Rearch Fellowship. We extend our deep appreciation to Dr. TARACHAND, (St. Stephens College) who gave us his precious time for calculating the radiation dosages and for helpful suggestions.

REFERENCES

BROWER, J. H. (1972) Interaction of age and radiation dosage on hatch of *Gibbium psylloides* eggs (Coleoptera : Plinidae). *Ann. ent. Soc. Am.*, **65** : 1237–1238.

BROWER, J. H. (1974) Age as a factor in determining radiosensitivity of eggs of *Plodia interpunctella*. *Environ. Ent.*, **3** : 945–946.

CLARK, A. M. & M. ROCKSTEIN (1964) Aging in insects, 1–227, *in*: *The Physiology of Insecta* Vol. I. (ed. M. ROCKSTEIN), Academic press, N. Y. & London.

COGBURN, R. R., E. W. TILTON & W. BURKHOLDER (1966) Gross effects of gamma radiation on the Indian meal moth and the angoumois grain moth. *J. econ. Ent.*, **59** : 682–684.

COLE, M. M., G. C. LABRECQUE & G. S. BURDEN (1959) Effect of gamma radiation on some insects affecting man. *J. econ. Ent.*, **52**: 448–450.

EL SAYED, E. I. & J. B. GRAVES (1969) Effects of gamma radiation on the tobacco budworm. III. Irradiation of eggs and larvae. *J. econ. Ent.*, **62** : 296–298.

GONEN, M. & I. FISHBAIN (1974) Sensitivity of different-age eggs of the tropical warehouse moth, *Ephestia cautella* (WALH.) (Lepidoptera: Phycitidae), to gamma radiation. *Phytoparasitica*, **2** : 47–49.

HENSHAW, P. S. & C. T. HENSHAW (1933) Changes in susceptibility of *Drosophila* eggs to alpha particles. *Biol. Bull.*, **64** : 348–357.

HOUGH, W.S. (1963) Effects of gamma radiation on calling moth eggs. *J. econ. Ent.*, **56** : 660–663.

PROVERBS, M. D. & J. R. NEWTON (1962) Influence of gamma radiation on the development and fertility of the codling moth, *Carpocapsa pomonella* (L.). *Can. J. Zool.*, **40** : 401–420.

REICHLE, D. E. (1969) Lethal effects of gamma radiation on eggs and larvae of the bagworm *Thyridopteryx ephemeraeformis*. *Ann. ent. Soc. Am.*, **62** : 1113–1117.

VEREECKE, A. & C. PETERENTS (1969) Sensitivity to gamma radiation to *Tribolium confusum* eggs at various developmental stages. *Entomologia exp. appl.*, **12** : 62–66.

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FOOD INTAKE AND MIDGUT PROTEASE ACTIVITY IN THE RED COTTON BUG, *DYSDERCUS CINGULATUS* FABR. (HETEROPTERA : PYRRHOCORIDAE)

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The adult female red cotton bug, *Dysdercus cingulatus* fed on soaked cotton seeds shows definite patterns of quantity of food ingested and midgut protease activity during the first gonotrophic cycle. The peak midgut protease activity is shown by the 5 day old insect which also consumes the maximum amount of food. Feeding the animal only distilled water or sucrose solution results in very low protease activity. On the contrary, feeding casein solution results in higher protease activity. It appears that proteins in the food stimulate midgut protease activity in this insect.

(*Key words:* **food intake, midgut protease,** *Dysdercus cingulatus*)

INTRODUCTION

The probable regulatory mechanisms involved in the secretion of digestive enzymes in insects have been reviewed by DADD (1970), HOUSE (1974) and by GOODING (1975). Some degree of regulation of protease secretion in relation to food ingestion is proposed by many workers (SCHLOTTKE, 1937; LANGLEY, 1966; GOODING, 1966, 1972; ENGELMANN, 1969). In certain species of insects, proteins in the food stimulate midgut protease production (SHAMBAUGH, 1954; ISHAAYA *et al.*, 1971; AKOV, 1972; BRIEGEL, 1975). In this circumstance it was thought worthwhile to find out if food had any regulatory role in digestive enzyme secretion in the heteropteran insects. The present work indicates the extent to which food regulates midgut protease activity in the red cotton bug, *Dysdercus cingulatus*.

MATERIALS AND METHODS

For all the experiments, adult *Dysdercus cingulatus* reared in the laboratory (temperature 26–32° C; RH 98%; photoperiod 12 hours light and 12 hours dark) was used. Newly emerged adult insects were separated from the stock colony and these were designated 0 day old.

Midgut protease activity was estimated in four categories of insects: (i) insects allowed to feed on soaked cotton seeds, their normal food; (ii) starved insects, allowed to feed only on distilled water after adult emergence; (iii) sucrose-fed insects, allowed to feed only on 5% sucrose solution after adult emergence and (iv) casein-fed insects, allowed to feed only on 1% casein solution after adult emergence. In the first category of insects, midgut protease was estimated using insects belonging to 8 age groups (days 0, 1, 2, 3, 4, 5, 6 and 7). In the remaining 3 categories, enzyme estimation was performed using the insects of 7 age groups (days 1, 2, 3, 4, 5, 6 and 7).

Preparation of the enzyme extract

The method followed for the preparation of the enzyme extract was that of APPLEBAUM *et al.* (1964) with minor modifications. Citrate-phosphate buffer (pH 6.2) was used for the preparation of the extract. Brei of the midguts was suspended in cold buffer and made upto one midgut per ml. The supernatant of the homogenate obtained after centrifugation was used as enzyme extract for enzymatic evaluation. This procedure helped to obtain the enzyme extarct with minimum loss of activity.

Determination of protease activity

The procedure of BIRK *et al.* (1962) as used by ISHAAYA *et al.* (1971) was followed for the determination of protease activity. The absorbancy o

the reaction mixture was read as OD units using quartz cuvettes and Beckman DU spectrophotometer at a wavelength of 280mμ, against a blank in which the enzyme extract was substituted by demineralised water. In all the determinations a duplicate sample whose enzyme extract was denatured by boiling at 100° C for 10 minutes before addition of the substrate solution, was also run side by side as control. The difference between the OD of these two samples was taken as the OD of the experimental sample. Protease activity of the experimental insects was represented as μg tyrosine liberated per midgut per hour using 0.008% tyrosine solution as the standard.

Optimum pH for protease activity was found out using the enzyme extract at different pH values (with citrate-phosphate buffer) ranging from pH 4.6 to 6.4, as the midgut pH of the insect showed this range (MURALEEDHARAN, 1977). For the determination of Michaelis constant (Km), protease activity was estimated using the enzyme extract with different concentrations of substrate solution. In order to demonstrate the relationship between the incubation time and the enzyme activity, protease activity was estimated after incubating the reaction mixture for varying periods of time. Protease activity was estimated using the enzyme extract at different concentrations in order to show the relationship between the concentration of the enzyme extract and the enzyme activity shown.

Statistical analysis of the data

An IBM system 1620 computer was used for calculations. Analysis of variance and Student's "t" test was carried out to assess the significance of the results.

Feeding experiments

As the presence of the opposite sex is likely to affect food intake, a devious method was chosen to eliminate this factor from affecting the experiment. In three small petridishes (5 × 1.5 cm) approximately equal but accurately pre-weighed soaked cotton seeds were taken and each was covered with wire-gauze. The petridishes were placed in separate plastic basins of identical dimensions. Five 0 day old females and five 0 day old males were set free into one basin. Into the second basin, five 0 day old females and ten 0 day old males were set free. The insects in both these basins were free to probe and feed on cotton seeds in the petridish through the wire mesh which prevented the excreta from falling into the petridish. The third basin, containing no insects served as control to determine weight-loss of cotton seeds due to evaporation. All the three basins were covered with white cloth. After 24 hours, the weight of each cotton seed sample was determined. Loss of weight from the control dish due to evaporation was subtracted from the other two dishes, which gave the weight loss due to feeding. The seeds were discarded and pre-weighed fresh seeds were again taken in each of the dishes. In this way the weight loss of the seeds in each of the three samples was determined during the seven consecutive days separately. From these values, the quantity of food ingested by one female on each of the days was calculated. If there was any mortality on any day, the values of that set was discarded. Mean value of ten sets of experiments was calculated

RESULTS

Influences of various factors of incubation on enzyme activity are shown in Figs. 1–4. The pattern of midgut protease activity shown during the first gonotrophic cycle by the insects fed on soaked cotton seeds, their normal diet, is shown in Fig. 5. As is evident from the figure, the least enzyme activity is shown by 0 day old insect while the peak level is seen in the 5 day old insect. Protease activity in the starved insects is significantly lower than those fed on cotton seeds ($P \leq 0.01$). The enzyme activity in the insects fed on only sucrose is even lower (Fig. 5). However, these differences are statistically not significant at five per cent level. The pattern of protease activity of insects fed on casein only is evident from Fig. 5. Insects 1, 2, and 3 day old, show significantly greater protease activity than that shown by insects fed on cotton seeds ($P \leq 0.01$). However, in the 4, 5, 6, and 7 day old insects, the enzyme levels are significantly lower than that found in insects fed on cotton seeds, at five per cent level.

The feeding pattern of the insect is shown in Fig. 6. Maximum food is consumed by 5 day old insects while the minimum quantity is ingested by the 1 day old insect.

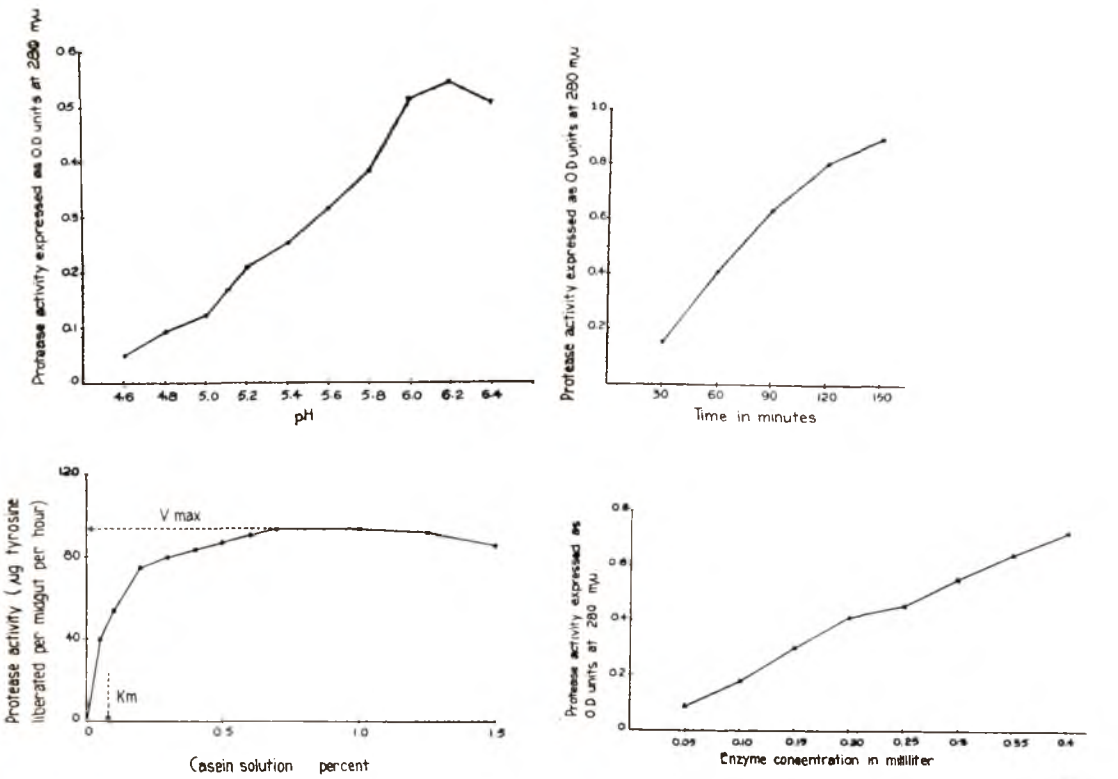

Fig. 1. (upper left) Effect of pH on midgut protease activity in *Dysdercus cingulatus* at 37° C during 60 min incubation. Fig. 2. (lower left) Effect of substrate concentration on midgut protease activity in *D. cingulatus* at pH 6.2 at 37° C during 60 min incubation. Fig. 3. (upper right) Midgut protease activity of *D. cingulatus* versus incubation time at pH 6.2 at 37° C. Fig. 4. (lower right) Relationship between the concentration of enzyme extract and midgut protease activity in *D. cingulatus* at pH 6.2 at 37° C during 60 minutes of incubation.

DISCUSSION

Present investigations reveal that in the newly emerged female *Dysdercus cingulatus,* midgut proteases are present though at a low level. A residual level of midgut enzyme is noticed in many other species of insects like the black flies and mosquitoes (YANG & DAVIES, 1968; SHAMBAUGH, 1954; AKOV, 1972). In many other species of insects like *Tenebrio molitor* (DADD, 1961) *Calliphora erythrocephala* (THOMSEN & MOLLER, 1963) and in *Rhodnius prolixus* (PERSAUD & DAVEY, 1971) definite patterns of midgut protease activity is shown by the females of different age groups. The present study also reveals that the pattern of midgut protease activity in *Dysdercus cingulatus* is comparable to vitellogenic activity. The daily increase in the total protein content of the ovary of *Dysdercus cingulatus* during the first gonotrophic cycle has been demonstrated by PRABHU & NAYAR (1971). Their observations show that a significant increase in the total protein content of the ovaries is noticed in 3, 4, 5 and 6 day old insects. This type of co-ordination between the gonotrophic cycle and the secretion of the midgut digestive enzymes is noted in many other insect species like *Nauphoeta cinerea*

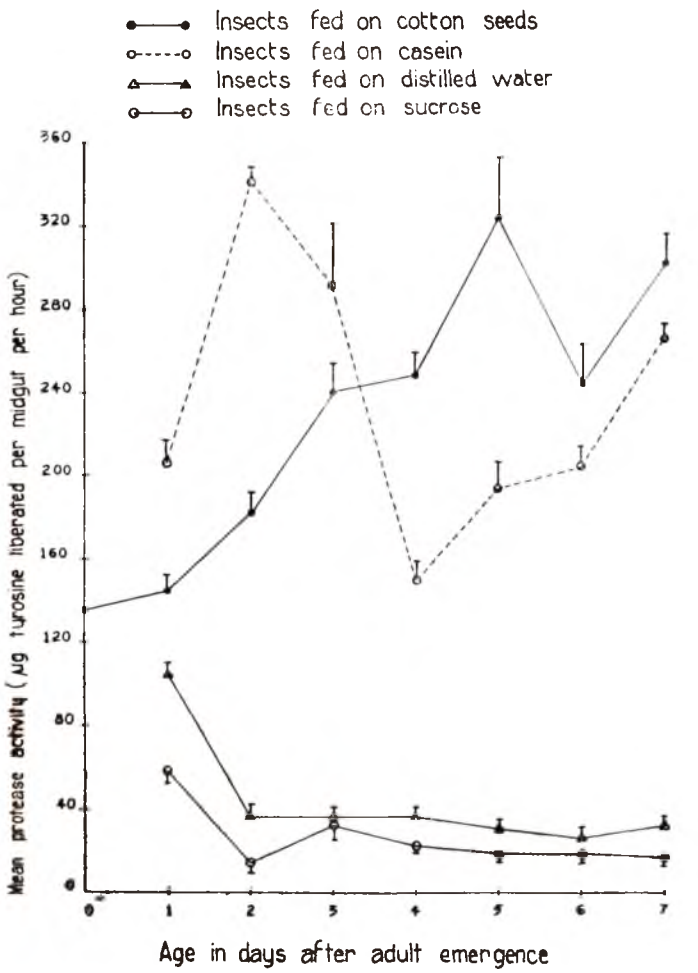

Fig. 5. The pattern of midgut protease activity shown by 1 to 7 day old adult female *D. cingulatus* fed on different diets. Each point represents mean of ten values. Vertical lines denote SEM.

(RAO & FISK, 1965) and in *Aedes atropalpus* (HUDSON, 1970). Thus it becomes evident that there exists a close relationship between oogenesis and the midgut protease activity in *Dysdercus cingulatus*. A high level of protease activity apparently leads to greater protein digestion and an increased availability of precursors in the haemolymph for the synthesis of yolk proteins during vitellogenesis. Vitellogenesis starts in the 3 day old insects and continues in the 4 and 5 day old *Dysdercus cingulatus* (JALAJA & PRABHU, 1971) and is completed in the 6 day old insects (JALAJA & PRABHU, 1976) and this may be the reason why the 6 day old insects show a steep decrease in the midgut protease activity. From the studies of digestion and ovarian development, DETINOVA (1962) concludes that the completion of vitellogenesis slows down digestion in *Anopheles macculipennis*. According to HUDSON (1970), *Aedes atro-*

Fig. 6. The pattern of ingestion of food by 1 to 7 day old adult female *D. cingulatus*. Each point represents mean of ten values. Vertical lines denote SEM.

palpus with mature or nearly mature eggs is incapable of synthesising or releasing normal quantities of digestive enzymes. In the 7 day old *Dysdercus cingulatus* the second batch of eggs start developing. A corresponding increase in the midgut protease level is also noted. Similar observations are made in *Rhodnius prolixus* (PERSAUD & DAVEY, 1971) and in *Dysdercus fasciatus* (GEERING-SACHER, 1972).

Ingestion of food (blood) stimulates secretion of midgut protease in haematophagous insects like black flies (DAVIES & YANG, 1968), *Aedes aegypti* (YANG & DAVIES, 1971) and in *Rhodnius prolixus* (PERSAUD & DAVEY, 1971). FISK & SHAMBAUGH (1954) demonstrate an increase in the midgut invertase activity in *Aedes aegypti* after ingestion of blood meal. The act of feeding stimulates enzyme secretion in certain other species of insects also (SCHLOTTKE, 1937; DADD, 1956; NUORTEVA & LAUREMA, 1961; GOODING, 1966). Feeding is found to stimulate the secretion of protease and maltase in *Dysdercus koenigii* while the secretion of sucrase is not affected by feeding (SAXENA, 1955). It may be observed from the present studies that peak level of midgut protease activity is observed in insects which consume the maximum amount of food. The ultrastructural observations of the midgut cells of certain insects also support these findings. For example, in the unfed females of *Aedes aegypti*, the rough surfaced endoplasmic reticulum is organised into compact whorls or finger print like structures. A few minutes after the intake of food, the whorls start to unfold indicating the synthesis of proteins, possibly digestive enzymes. After blood digestion is completed, the compact structure is restituted (BERTRAM & BIRD, 1961; STAUBLI *et al.*, 1966). The greater incorporation of ^{14}C leucine into proteins of the midgut in the fed *Leucophaea maderae*, but to a lesser extent in the starved ones support the hypothesis that protease synthesis is stimulated by food intake (ENGELMANN, 1969). The present studies also reveal that when *Dysdercus cingulatus* consumes greater amount of food, a corresponding increase in the midgut protease activity is also noted. The peak level of protease activity is shown by the 5

day old insects which consume the maximum amount of food.

In the 1, 2 and 3 day old insects, fed on only casein, the midgut protease level is even higher than that fed on soaked cotton seeds. On the contrary, in *Dysdercus cingulatus* fed on only sucrose, no significant difference in the midgut protease activity can be noticed among the insects of different age groups and the level of protease activity is much lower than that shown by those fed on cotton seeds. Similarly no significant fluctuations can be noticed in the midgut protease activity of insects of different age groups which were allowed to feed only on distilled water. Saline fed *Glossina morsitans* and starved *Tenebrio molitor* also show poor midgut protease activity (LANGELY, 1966; DADD, 1961). Thus it seems that proteins in the diet have a stimulatory effect on the midgut protease activity in *Dysdercus cingulatus*. In *Leucophaea maderae*, protein diets like fibrin, glutenin and elastin increase intestinal protease activity (ENGELMANN, 1969). Similarly, in the larvae of *Spodoptera littoralis*, an increase in the protein content of the diet shows a corresponding increase in the midgut protease activity (ISHAAYA *et al.*, 1971). In *Aedes aegypti*, secretion of midgut trypsin is induced by its substrate (globular proteins) and when the substrate is digested, enzyme secretion stops (BRIEGEL, 1975). The residual levels of midgut protease activity noticed in the 1 day old insects fed either on sucrose or on distilled water can be due to the stimulation by the food still present in their gut. However, in *Tenebrio molitor* protease activity increases after feeding on corn flour, cellulose or water also (DADD, 1956). In the light of the present findings, it may be suggested that in *Dysdercus cingulatus* protein is necessary in the diet for stimulation of protease activity in the midgut.

Acknowledgements:– We thank Professor K. M. ALEXANDER for the facilities afforded in the Department. DM is grateful to the University of Kerala for the fellowship awarded while this work was being carried out.

REFERENCES

AKOV, S. (1972) Protein digestion in haematophagous insects, *in*: *Insect and Mite Nutrition* (ed. RODRIGUEZ, J. G.), North-Holland Publishing Company, Amsterdam.

APPLEBAUM, S. W., I. HARPAZ & A. BONDI (1964) Amylase secretion in the larvae of *Prodenia litura* F. (Insecta). *Comp. Biochem. Physiol.*, **13**: 107–111.

BERTRAM, D. S. & R. G. BIRD (1961) Studies on mosquito-borne viruses in their vectors. 1. The normal fine structure of the midgut epithelium of the adult female *Aedes aegypti* (L.) and the functional significance of its modification following a blood meal. *Trans. R. Soc. trop. Med. Hyg.*, **55** : 404–423.

BIRK, Y., I. HARPAZ, I. ISHAAYA & A. BONDI (1962) Studies on the proteolytic activity of the beetles, *Tenebrio* and *Tribolium*. J. *Insect Physiol.*, **8** : 417–429.

BRIEGEL, H. (1975) Excretion of proteolytic enzymes by *Aedes aegypti* after a blood meal *J. Insect Physiol.*, **21** : 1681–1684.

DADD, R. H. (1956) Proteolytic activity of the midgut in relation to feeding in the beetle, *Tenebrio molitor*. *J. exp. Biol.*, **33** : 311–324.

DADD, R. H. (1961) Evidence for humoral regulation of digestive secretion in the beetle *Tenebrio molitor*. *J. exp. Biol.*, **38** : 259–266.

DADD, R. H. (1970) Digestion in Insects, 117–145, *in* : *Chemical Zoology*, Vol. **5** (ed. FLORKIN, M. & B. T. SCHEER), New York and London Academic Press.

DAVIES, D. M. & Y. J. YANG (1968) Enzyme activity and digestion in adult black flies (Simuliidae, Diptera). *Proc. Thirteenth International Congress of Entomology*, 370–371.

DETINOVA, T. S. (1962) Age-grouping methods in Diptera of medical importance. *World Health Organization Monographs series* No. ' : 55

ENGELMANN, F. (1969) Food-stimulated synthesis of intestinal proteolytic enzymes in the cockroach *Leucophaea maderae*. *J. Insect Physiol.*, **15** : 217–235.

FISK, F. W. & G. F. SHAMBAUGH (1954) Invertase activity in adult *Aedes aegypti* mosquitoes. *Ohio J. Sci.*, **54** : 237–239.

GEERING-SACHER, K. (1972) Studies on digestive proteinase activity in the midgut of adult *Dysdercus fasciatus* (Hemiptera). *J. Insect Physiol.*, **18** : 2071–2076.

GOODING, R. H. (1966) In vitro properties of proteinases in the midgut of adult *Aedes aegypti* L. and *Culex fatigans* (WIEDEMAN). *Comp. Biochem. Physiol.*, **17** : 115–127.

GOODING, R. H. (1972) Digestive processes of haematophagous insects. 1. A literature review. *Questiones Entomol.*, **8** : 5–60.

GOODING, R. H. (1975) Digestive enzymes and their control in haematophagous arthropods. *Acta trop.*, **32** : 96–111.

HOUSE, H.L. (1974) Digestion, 63–111, *in*: *The Physiology of Insecta*, Vol. V, 2nd ed. (ed. ROCKSTEIN, M.), Academic Press, New York and London.

HUDSON, A. (1970) Factors affecting egg maturation and oviposition by autogenous *Aedes atropalpus* (Diptera : Culicidae). *Can. Ent.*, **102:** 939–949.

ISHAAYA, I. ,1. MOORE & D. JOSEPH (1971) Protease and amylase activity in larvae of the Egyptian cotton worm, *Spodoptera littoralis*. *J. Insect Physiol.*, **17** : 945–953.

JALAJA, M. & V. K. K. PRABHU (1971) Blood protein concentration in relation to vitellogenesis in *Dysdercus cingulatus*. *Experientia*, **27** : 639–640.

JALAJA, M. & V. K. K. PRABHU (1976) Effect of the chemosterilants apholate and metepa on the ovaries of the red cotton bug, *Dysdercus cingulatus* FABR. (Insecta, Heteroptera, Pyrrhocoridae). *Entomon*, **1** : 43–53.

LANGLEY, P. A. (1966) The control of digestion in the tse-tse fly, *Glossina morsitans*. Enzyme activity in relation to the size and nature of the meal. *J. Insect Physiol.*, **12**: 439–448.

MURALEEDHARAN, D. (1977) Studies on some aspects of digestion in *Dysdercus cingulatus* FABR. (Heteroptera : Pyrrhocoridae). Ph. D. thesis, University of Kerala.

NUORTEVA, P. & S. LAUREMA (1961) Observations on the activity of salivary proteases and amylases in *Dolycoris baccarum* (L.) (Het., Pentatomidae). *Ann. Ent. Fenn.*, **27** : 93–97.

PERSAUD, C. E. & K. G. DAVEY (1971) The control of protease synthesis in the intestine of adults of *Rhodnius prolixus*. *J. Insect Physiol.*, **17** : 1429–1440.

PRABHU, V. K. K. & K. K. NAYAR (1971) Protein and free amino acid concentration in the blood and total ovarian proteins in *Dysdercus cingulatus* FABR. (Heteroptera) during reproduction. *Comp. Biochem. Physiol.*, **11** : 961–971.

SAXENA, K. N. (1955) Studies on the passage of food, hydrogen ion concentration and enzymes in the gut and salivary glands of *Dysdercus koenigii* FABR. (Pyrrhocoridae: Heteroptera). *J. zool. Soc. India*, **7** : 145–154.

SCHLOTTKE, E. (1937) Untersuchungen über die Verdaungsfermente von Insekten. I. Die verteilung der fermente im Darmkanal von fleischfressen den Carabiden und die Anderungen ihrer Konzentration während der Verdaung. *Z. vergl. Physiol.*, **24** : 210–247.

SHAMBAUGH, G. F. (1954) Protease stimulation by food in adult *Aedes aegypti* LINN. *Ohio J. Sci.*, **54** : 151–160.

STAUBLI, W., T. A. FREYVOGEL & J. SUTER (1966) Structural modification of the endoplasmic reticulum of midgut epithelial cells of mosquitoes in relation to blood intake. *J. microscopie*, **5** : 189–204.

THOMSEN, E. &I. MOLLER (1963) Influence of neurosecretory cells and of corpus allatum on intestinal protease activity in the adult *Calliphora erythrocephala* MEIG. *J. exp. Biol.*, **40** : 301–321.

YANG, Y. J. & D. M. DAVIES (1968) Amylase activity in black flies and mosquitoes (Diptera). *J. med. Ent.*, **5**: 9–13.

YANG, Y. J. & D.M. DAVIES (1971) Digestive enzymes in the excreta of *Aedes aegypti* larvae. *J. Insect Physiol.*, **17** : 2119–2123.

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HISTOLOGICAL STUDY OF NEUROSECRETION IN THE PUPA OF *HELIOTHIS ARMIGERA* HUB. (LEPIDOPTERA : NOCTUIDAE)

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(*Received 28 July 1977*)

Changes in the activity of neurosecretory cells of the brain have been studied during the developmental period of the pupa of *Heliothis armigera* at 24 hour intervals. The number of median and lateral neurosecretory cells remains constant throughout the development of the pupa but the number of median neurosecretory cells is nearly double in the pupa as compared to the Vth instar larva. Only one neurosecretory cell has been observed in the optic lobe. After forming more or less S shaped curve the axons bifurcate, one branch innervates the cmopound eye and the other goes back to the brain.

(*Key words:* **Neurosecretion, pupa,** *Heliothis armigera*)

INTRODUCTION

From the survey of literature (VAN DER KLOOT, 1960; HIGHNAM, 1965; BERN & HAGADORN, 1965; GABE, 1966; MADDRELL, 1967 *etc.*), it will be apparent that much of the emphasis has been given to study the neurosecretory system in larval and adult stages of insects in relation to the growth and reproduction. Only very few publications deal with the pupal stage. According to WIGGLESWORTH (1965) most of the internal organs change considerably during this stage. Similar observations have also been made in the case of neurosecretory cells in the brain of ants (GAWANDE, 1968). The present studies have been undertaken to find out the changes in the neurosecretory activity in the pupa of *Heliothis armigera.*

MATERIALS AND METHODS

Larvae of different stages of *Heliothis armigera* were collected from gram fields. Only four larvae were kept in each petridish (15×2.5 cm) to avoid cannibalism. The larvae were maintained at constant temperature of 90 ± 2° F. Every day the larvae were provided with tender twigs of gram crop along with the pods as food. The larvae which were about to pupate were transferred to galvanised iron sheet trays (30×20×15 cm) containing moist soil upto a depth of 10 cm. These trays were examined daily. At pupation they were transferred to another tray which thus provided material of known age required for the study. The length of the pupal stage of *H. armigera* was found to be 8 days in the present investigation. Samples of 5 specimens were taken at 24 hr interval throughout the pupal stage. To eliminate possible diurnal alterations in neurosecretory activity, all pupae were fixed at 09.00 hr.

Specimens were anaesthetized with carbon dioxide and the brain was dissected out under a binocular microscope. Material was fixed in aqueous Bouin's solution under air pressure of 600 farr obtained by water pump. After 24 hr of fixation in Bouin's fluid tissues were processed as usual and embedded in paraffiin wax. Sections were cut at 5μ and stained with paraldehyde-fuchsin (GOMORI, 1950) after the modification of GABE (1953). Quantity of neurosecretory material was graded on a one-to-five scale.

OBSERVATIONS AND DISCUSSION

Neurosecretory Cells (NC) of the brain

i. The median neurosecretory cells(MNC): In the fifth instar larva of *Heliothis armigera*, the MNC are only nine and are scattered (Fig. 1). The number however increases to

twenty-two during prepupal stage. Similar observations have been made by GAWANDE (1968) in ants. But the number remains more or less constant during the pupal development (Table 1). Identical observations have been made by VIJVERBERG (1970) in *Calliphora erythrocephala.*

TABLE 1. Relation between age of the pupa and the number of MNC and LNC and their quantity of NSM (values represent average from 5 pupae for each age group).

Age of the pupa in days	Number of MNC	Quantity of NSM in MNC	Number of LNC	Quantity of NSM in LNC
1	26	+	5	+
2	27	++	5	++
3	20	+++	5	++
4	21	+++	5	++
5	19	++++	5	+++
6	24	+++++	5	+++
7	22	+++	5	++
8	20	++	5	+

The MNC of freshly formed pupa are more or less devoid of neurosecretory material (NSM). With the progress of the pupal period, the NSM becomes more and more evident in the perikaryon of NC (Figs. 2-3). Maximum amount of NSM is observed on sixth day after pupation (Fig. 4). After that the amount of NSM decreases rapidly towards the end of the pupal period (Table 1). Cylical changes in the NSM have been observed in the fifth instar larva of *Bombyx mori* (BOUNHIOL *et al.*, 1953), but so far no studies appear to have been made during pupal development.

ii. The lateral neurosecretory cells (LNC): Five NC are observed in a group at a distance from MNC (Fig. 2) which may be considered LNC. The axons of these cells could not be traced. The number of LNC also remains constant during the pupal development (Table 1). The amount of NSM accumulates slowly in the perikaryon of the LNC upto 6 days and later on it becomes less evident (Table 1).

iii. Neurosecretory cells in the optic lobes: Only one neurosecretory cell with distinct axon has been observed anteriorly in the optic lobe (Fig. 5). The axon of this cell runs downward forming more or less S shaped curve. Then the axon bifurcates. One of the branches innervates the compound eye and the other goes back to the brain. Similar observations have been made by BEATTIE (1971) in *Periplaneta americana* but the innervation to the compound eyes has not been reported.

REFERENCES

BEATTIE, T. M. (1971) Histology, histochemistry and ultrastructure of neurosecretory cells in the optic lobe of the cockroach, *Periplaneta americana*. *J. Insect Physiol.*, **17** : 1843–1855.

BERN, H. A. & I. R. HAGADORN (1965) Neurosecretion, 353–429, *in : Structure and function in the nervous system of Invertebrates*, Vol. I (ed. BULLOCK, T. H. & G. A. HORRIDGE), Freeman and Co., San Francisco and London.

BOUNHIOL, J. J., M. GABE & L. ARVY (1953) Donnees histophysiologiques sur la neurosecretion chez *Bombyx mori* L. et sur rapports avec les lgandes endocrines. *Bull. biol. Fr. Belg.*, **87** : 323–333.

GABE, M. (1953) Quelques applications de la Coloration par la fuchsine–paraldehyde. *Bull. Microsc. appl.*, **3** : 153–162.

GABE, M. (1966) *Neurosecretion*, Pergamon Press, Oxford, 872 pp.

GAWANDE, R. B. (1968) A histological study of neurosecretion in ants (Formicoidea). *Acta ent. bohemoslov.*, **65** : 349–363.

GOMORI, G. (1950) Aldehyde-funcsin. A new stain for elastic tissue. *Am. J. clin. Path.*, **20** : 665–668.

HIGHNAM, K. C. (1965) Some aspects of neurosecretion in Arthropods. *Zool. Jb. Physiol.*, **71**: 558–582.

MADDRELL, S. H. P. (1967) Neurosecretion in insects, 103–118, *in : Insects and Physiology* (ed. BEAMENT, J. W. L. & J. E. TREHERNE), Oliver and Boyd Ltd., Edinburgh and London.

VAN DER KLOOT, W. G. (1960) Neurosecretion in insects. *A. Rev. Ent.*, **5** : 35–52.

VIJVERBERG ,A. J. (1970) The larval and pupal neurosecretory system of *Calliphora erythrocephala* MEIGN. Histology and activity of neurosecretory cells in the brain and suboesophageal ganglion. *Neth. J. Zool.*, **20** : 353–379.

WIGGLESWORTH, V. B. (1965) *Principles of Insect Physiology*, Methuen, London, 6th ed. 741 pp.

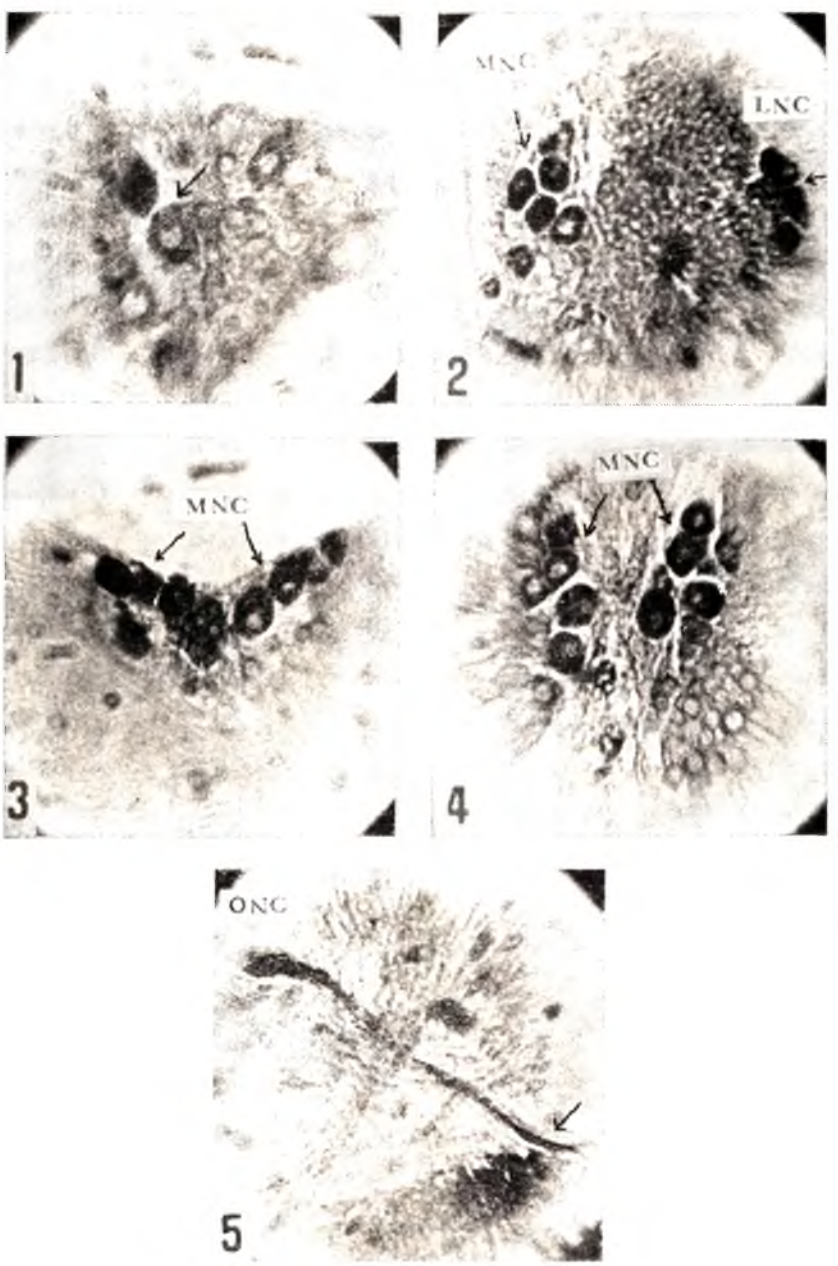

Fig. 1. Neurosecretory cells (NC) in the pars intercerebralis (PIC) of the brain of V instar larva. NSC are scattered and stained lightly; Fig. 2. Median (MNC) and lateral (LNC) neurosecretory cells in the PIC of the brain of the 3 day pupa; Fig. 3. MNC are deeply stained in 5 day pupa; Fig. 4. MNC are very intensely stained in 6 day pupa; Fig. 5. Neurosecretory cell in the optic lobe (ONC) with well stained axon. The axon bifurcates at the end. All sections are frontal, stained with paraldehyde-fuchsin (× 450).

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CYTOLOGY OF *TESSARATOMA JAVANICA* (THUNBERG) (PENTATOMIDAE : HETEROPTERA)

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(*Received 10 August 1977*)

The diploid chromosome number in male *Tessaratoma javanica* (THUNBERG) is 12 (2n = 10+XY). Chromosomes can be classified as a single pair of large, two small, and the remaining eight medium sized bodies. The chromosomes, X and Y, are unequal in their length. The meiosis is normal with typical Pentatomid type.

(*Key words:* **Chromosome cytology, *Tessaratoma javanica*, Pentatomid**)

INTRODUCTION

MAKINO (1951) gave an account of the available information on chromosome numbers in Heteroptera. In the course of their extensive chromosome study on Heteroptera, TAKENOUCHI & MURAMOTO (1969) brought out an up-to-date list of chromosome numbers. MIKOLAJSKI (1972) investigated the cytology of 49 species of Pentatomorpha. MURAMOTO (1973) reviewed the chromosome numbers of Heteropteran insects of Japan. *Tessaratoma javanica* (THUNBERG), a member of the subfamily Tessaratominae, is distributed throughout India. To the authors knowledge there is no report on the chromosome complement of *T. javanica*.

MATERIALS AND METHODS

Adult bugs of *Tessaratoma javanica* feeding on soapnut tree (*Sapindus emarginatus*–Sapindaceae) were collected. It has been reported (MEHRA & PURAKARASTHA (1957) that *T. javaniva* is a sporadic pest of safflower (*Carthamus tinctorius*–Compositae). These bugs have characteristic repugnant odour when disturbed. The insects were maintained on soapnut tree leaves in the laboratory at room temperature. The males were dissected out for their testes and fixed in acetic alcohol (1 : 3). For cytological studies, the material was processed as haematoxylin squashes.

RESULTS AND DISCUSSION

Spermatogonial metaphase chromosomes are illustrated in Fig. 1 which shows twelve chromosomes. It is difficult to distinguish X and Y chromosomes at this stage. A careful study of their meiotic stages show that the autosomes are fairly large in comparison to sex chromosomes. Autosomes can be classified as single pair of large and 8 medium sized bodies. This was further confirmed by screening a large number of metaphases I & II. At metaphase I four equal-sized bivalents are clearly seen (Fig. 6). Sex chromosomes cannot form a true bivalent and they segregate from one another to second metaphase instead of at the first metaphase as in most other Heteropteran insects so far studied. The first division of meiosis is reductional for the autosomes and second division for the sex chromosomes. Meiosis is characterised by a diffuse stage prior to diplotene (Fig. 2). At diplotene seven elements can be distinctly counted of which five are autosomal bivalents and the X Y are univalent chromosomes (Fig. 3). Two ring like bivalents are seen during early diakinesis and complete terminalisation at the end (Figs. 4 & 5). All the seven elements of the metaphase I show

a tendency to form a ring (Fig. 6) with the sex chromosomes in the centre. In metaphase II the pseudo-bivalent (Fig. 7) of the heteromorphic sex chromosomes is quite common. This phenomenon seeems to be a prerequisite for the orderly distribution of the sex chromosomes in the meiotic divisions. *Eumenotes obscura* (2n = 14) described by MANNA (1951) is the first cytological record in the subfamily Tessaratominae. PARSHAD (1957) added *Eusthenes saevus* with diploid number 12. *Tessaratoma javanica* discribed in the present studies represents 12 as diploid number. Based on I & II meiotic divisions and their measurements *E. obscura* chromosomes can be classified into one large, one medium sized, one small and five submedium sized bodies. X is the smaller member of the submedium sized and Y is the smallest chromosome. Occurrence of X and Y as separate bodies at diplotene is common (MANNA, 1951). Spermatogonial metaphase of *E. saevus* reveals single pair of large, one small and remaining nine medium sized chromosomes. The chromosomes X and Y are unequal in their size. First and second meiotic divisions do not show any group pattern (PARSHAD, 1957). Meiotic chromosomes of *T. javanica* constitute one large, two small, and the remaining four medium sized bodies. X and Y are unequal in their length. Nuclear volume is large in all members of Tessaratominae so far studied. A large chromosome size seems to be a typical of the *T. javanica*. *T. javanica* shares some similarities with *E. saevus* and *E. obscura* as described above. While discussing chromosome diversity in the subfamily Asopinae, MANNA (1951) surmised that the reduction in chromosome number occurred through fusion of two non-homologous autosomes. Based on this assumption it is probable that diploid number of 12 in Tessaratominae might have originated from ancestral chromosome number 14.

The value of karyotypes, sex mechanism and modal numbers have been well documented in Heteropteran families (MANNA, 1951, 1962). Diploid number of the subfamily pentatominae varies from 6-27 with modal number 14. Among pentatomidae the chromosome of Coptosominae (VENKAT REDDY *et al.*, 1977) and Scutellerinae are uniform with diploid number 12 while some members of Dinidorinae (2n = 14 & 21) and Tessaratominae (2n=12 & 14) represent deviations. It is not possible to ascribe any modal number to Tessaratominae since only three species are worked out for their cytology. A careful metrical analysis of Pentatomid chromosomes (MANNA, 1951) and cytophotometric analysis of DNA could possibly throw more light on the problem of the evolution and interrelationship.

Acknowledgements:– The authors are grateful to Prof. K. VENKATA RAMIAH, Vice-Chancellor, and to Prof. S. S. SIMHA, Head, Department of Zoology, Kakatiya University, for facilities and encouragement. One of them (CJ) is indebted to Sri K. JAYASHANKAR, Principal, CKM College, Warangal for his encouragement and UGC, New Delhi, for financial assistance.

REFERENCES

MAKINO, S. (1951) Heterpotera, 125—151, *in: An Atlas of the chromosome numbers in Animals*. 2nd ed. The Iowa State College Press, Ames, Iowa.

MANNA, G. K. (1951) A study of the chromosomes during meiosis in forty-three species of Indian Hetroptera. *Proc. zool. Soc. Beng.*, **4**: 1–116.

MANNA, G. K. (1962) A further evaluation of cytology and interrelationships between various groups of Heteroptera. *Nucleus, Calcutta*, **5**: 7–28.

MEHRA, B. P. & B. K. PURAKARASTHA (1957) Field observations on a severe outbreak of *Tessaratoma javanica* (THUNBERG) a sporadic pest of Kusum (*Schleichera oleasa*) and preliminary trials on its control. *Indian J. Ent.*, **19**: 214–216.

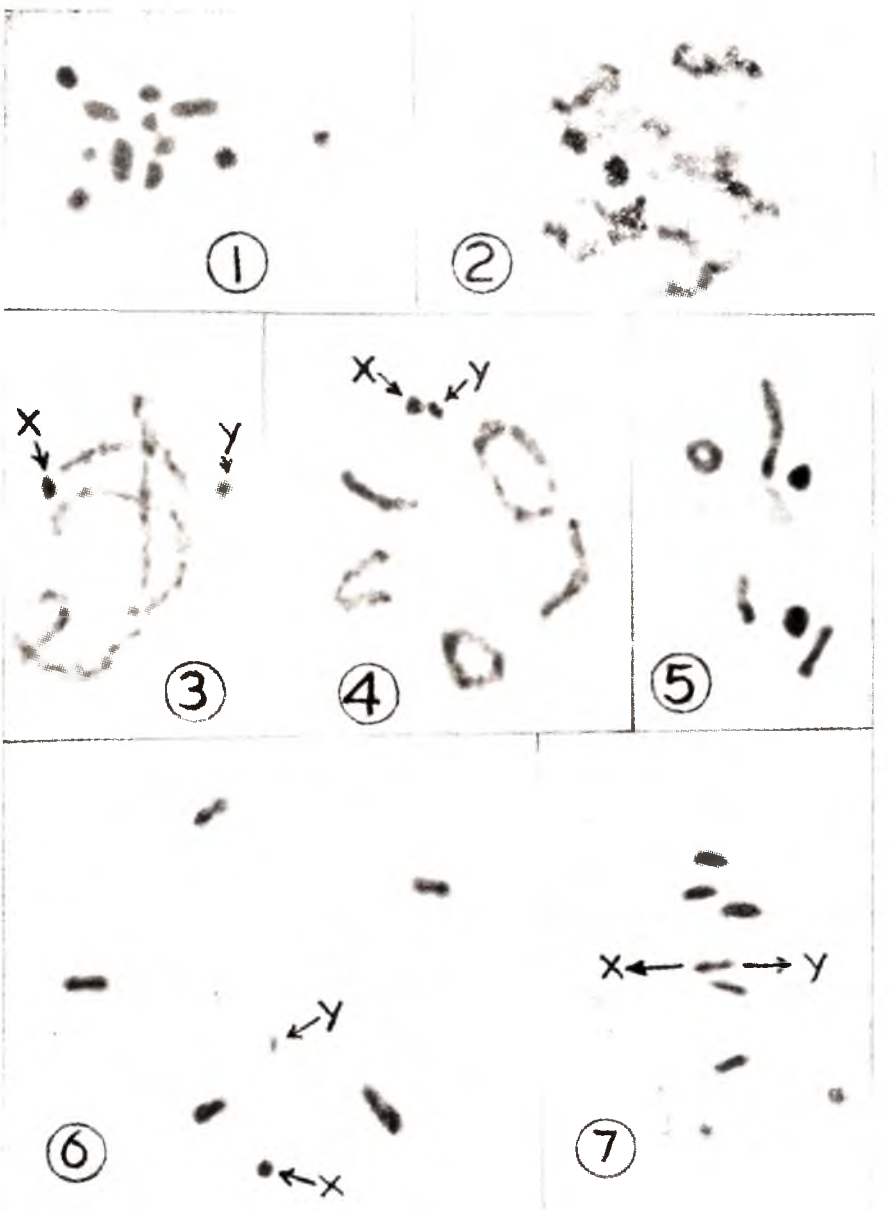
MIKOLAJSKI, M. (1972) Badania kariologiczne w obrebic pentatomorpha Lst., Pdg et Sw (Hemiptera–Heteroptera). *Zess nauk.* WSR *Olszt. Seria B Suplement*, **4**, 1–82.

MURAMOTO, N. (1973) A list of the chromosome numbers of heteropteran insects of Japan. *C. I. S.*, **14** : 29–31.

PARSHAD, R. (1957) Cytological studies in Heteroptera. IV. Chromosome complement and meiosis in twenty-six species of the Pentatomoidea, Lygaeoidea and Coreoidea with a consideration of the cytological bearing on the status of these superfamilies. *Res. Bull. Panj Univ. Sci.*, **133**: 521–559.

TAKENOUCHI, Y & N. MURAMOTO (1969) chromosome number of Heteroptera. *J. Hokkaido Univ. Educ.*, **IIB., 18**: 1–15.

VENKAT REDDY, P., C. JANAIAH & N. CHARI (1977) The Chromosomes of *Coptosoma indica* MONTAND. (Heteroptera—Plataspidae). *Curr. Sci.*, **46**: 230–231.



Chromosomes of *Tessaratoma javanica* (× 2000).

Fig. 1. Spermatogonial metaphase; Fig. 2. Bivalents emerging from the diffuse stage; Fig. 3. Late diplotene; Figs. 4 & 5. Early and late diakinesis; Fig. 6. Metaphase I; Fig. 7. Metaphase II side view showing pseudobivalent & five autosomal bivalents.

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BIOLOGY AND BEHAVIOUR OF *APOCRYPTA BAKERI* JOSEPH (TORYMIDAE), CLEPTOPARASITE OF *CERATOSOLEN MARCHALI* MAYR (AGAONIDAE)

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(Received 4 July 1977)

Apocrypta bakeri JOSEPH **is a cleptoparasite on** *Ceratosolen marchali* MAYR, **breeding in the gall figs of** *Ficus hispida* L. **Observations on certain aspects of the biology and behaviour are given. The morphology of the egg, larval, prepupal and pupal stages are briefly described. Six distinct generations of the parasitic wasps corresponding to six generations of** *C. marchali* **and six crops of figs in a year are traced. The adaptations of this parasite to its cleptoparasitic mode of life are discussed.**

(*Key words:* **biology, behaviour,** *Apocrypta bakeri*, **cleptoparasite,** *Ceratosolen marchali*)

INTRODUCTION

Apocrypta bakeri JOSEPH and *Philotrypesis pilosa* MAYR (both of the fam. Torymidae) parasitize the agaonid, *Ceratosolen marchali* MAYR, all these three insects breeding in the receptacles of *Ficus hispida* L. This paper deals with certain aspects of the biology and behaviour of *A. bakeri*, elucidating its parasitic relationship with *C. marchali*. It is for the first time that the biology and behaviour of a species of the genus *Apocrypta* is studied.

METERIALS AND METHODS

Ficus hispida is a very common tree in Calicut, where the work was undertaken. It is dioecious, the seed flowers and gall flowers developing on separate trees. The fig wasps are able to develop only in the gall producing ovaries of flowers produced by the second type of trees. For the details on the methods employed in the study, please refer to the account given by the same authors (ABDURAHIMAN & JOSEPH, 1976).

OBSERVATIONS AND DISCUSSION

Emergence, Copulation and Eclosion

The emergence of the male *Apocrypta* takes place almost simultaneously with that of the other inhabitants of the fig, namely *Ceratosolen marchali* and *Philotrypesia pilosa*. The process of emergence and the post-emergence behaviour of the males as well as females are similar to those observed in *Philotrypesis caricae* (GRANDI, 1930; JOSEPH, 1958). LICHTENSTEIN (1919) remarked that the eclosed males of *Philotrypesis* seem to dig themselves between the bases of the ovary of the fig as if to hide themselves'. However, it seems in *P. caricae* (JOSEPH, 1958) and in *A. bakeri*, this so-called digging behaviour is actually the searching behaviour (oriented by the chemoreception of the female sex pheromone) on the part of the males for the galls containing their females. This is evident from the experimentation using males in which the antennae were amputated soon after emergence. Such males wandered aimlessly and could not locate the specific galls containing their females. In controls with intact antennae, however, the gall flowers containing their specific females were successfully located and the enclosed females liberated.

A single male mates successively with two or three females, after liberating each from her gall. The act of copulation lasts

for a short period, usually about 3 to 5 seconds. MAYER (1882) and LICHTENSTEIN (1919) recorded the mating in *P. caricae* as mostly taking place while the females are inside their galls, though a few instances of mating were reported to take place outside also. JOSEPH (1958) could not observe the male copulating with any females still enclosed inside their galls. It could be concluded therefore that in *P. caricae* as well as in *A. bakeri* copulation takes place only after the female has come out of her gall into the cavity of the fig.

Eclosion of the *A. bakeri* females from the fig receptacle take place along with the females of *C. marchali* and *P. pilosa*. The general pattern of eclosion bears similarities with that reported in *C. marchali* (ABDURAHIMAN & JOSEPH, 1976). The *Apocrypta* females developed in a fig take two or three days for completing eclosion.

Longevity

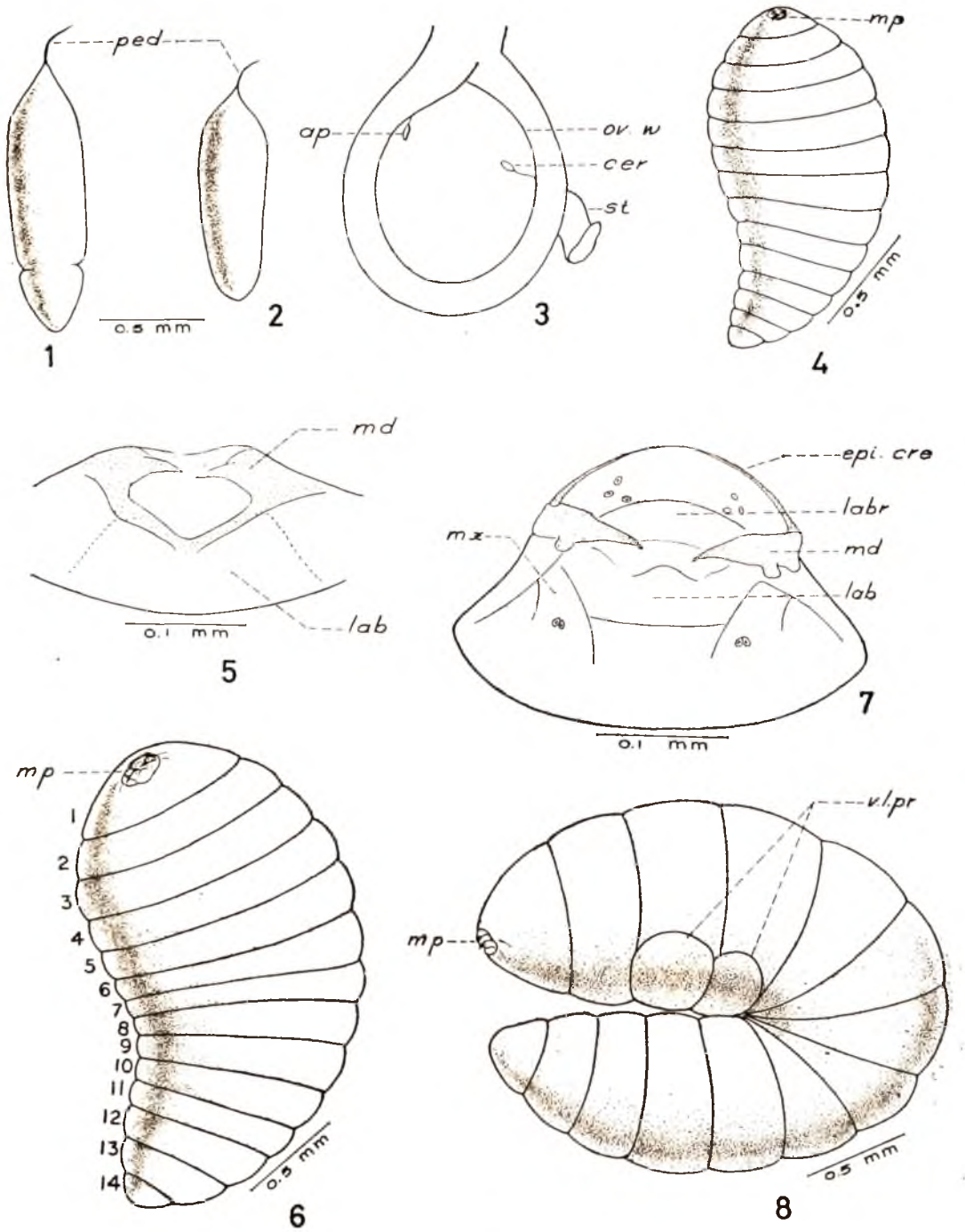
The males are short-lived, their longevity varying from 24 to 36 hours. The females that emerged during rainy season (when the atmosphere is uniformly cooler) survived for a period of 10 to 12 days, while those that emerged during the hot season survived for only 7 to 9 days. CONCI (1924) kept the females of *P. caricae* alive and active for 20 to 32 days; GRANDI (1921) could maintain them alive for only 15 to 25 days. JOSEPH (1958) kept them alive for 30 to 35 days. The wide variation reported for longevity of the two torymid genera may mainly be due to the differences in the prevailing climatic conditions like temperature, humidity, etc. in the localities concerned, as well as on varying capacities of tolerance of the concerned genera.

Oviposition

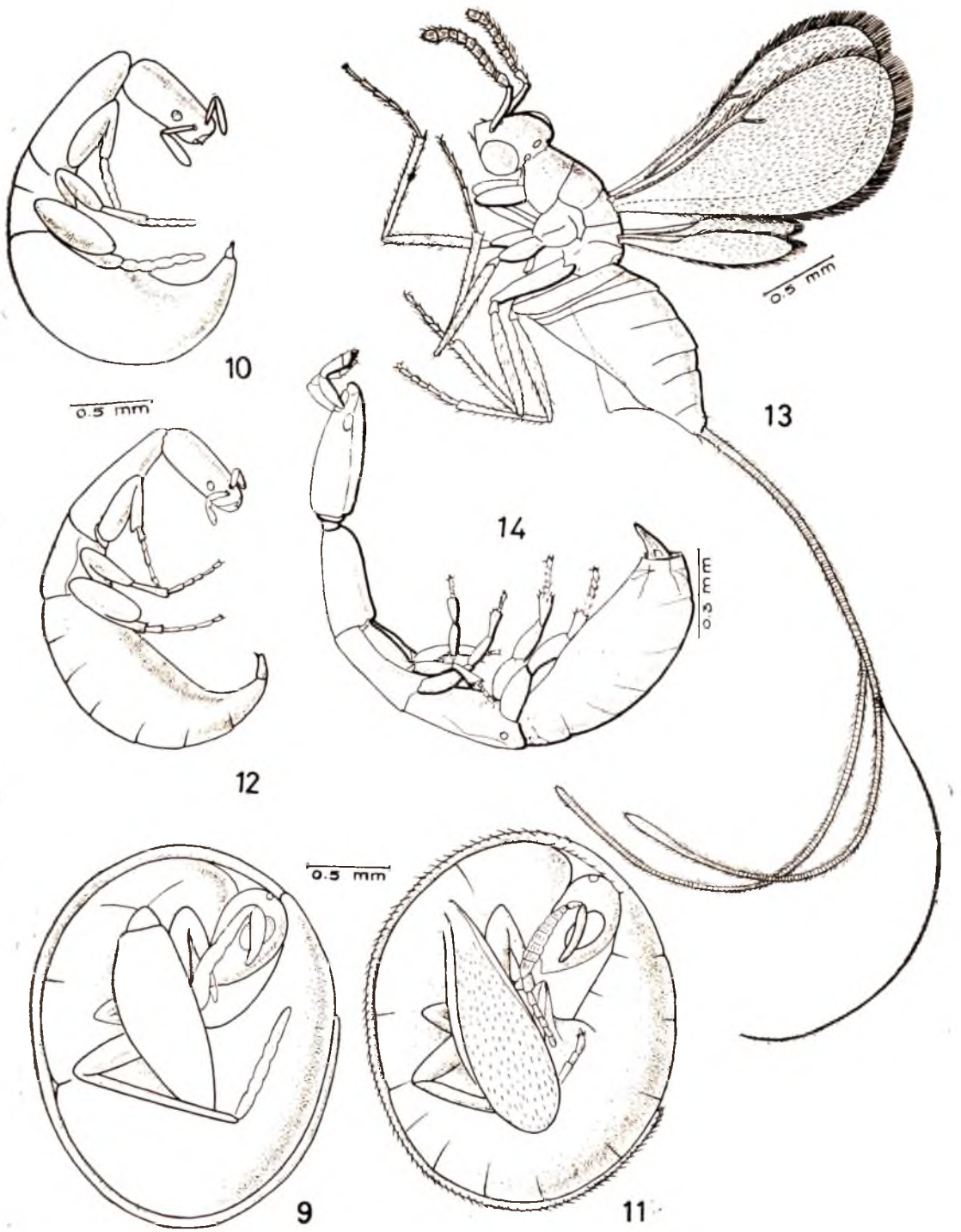
Egg deposition is accomplished by means of the long ovipositor which pierces the wall of the fig for reaching the fig ovaries. The presence of the ventral abdominal keel helps in lengthening the abdomen thereby facilitating easy penetration of the ovipositor. (A detailed account of oviposition behaviour will be published elsewhere).

The egg of *A. bakeri* comes to be deposited in the nucellus of *Ficus* ovary, normally away from the region of the style, with the small stalk of the egg attached to the ovarian wall. The eggs are always deposited only in those ovaris where the host *Ceratosolen* has already deposited her egg and injected the secretions of her well developed poison gland. This secretion induces the parthenogenetic development of the endosperm of the fig ovary which divides to produce a gall serving as food for the developing larvae of both *Ceratosolen* and *Apocrypta*. When tender figs free of *Ceratosolen* eggs were provided to the females of *A. bakeri*, they did not oviposit, though they attempted to do so. *Apocrypta* females also did not oviposit in those ovaries of *Ficus* containing the *Philotrypesis* eggs along with *Ceratosolen* eggs, thus avoiding possible parasitic competition among the two torymids. The presence of the secretion of the poison glands injected by the agaonid host into the fig ovary is ascertained by the female *A. bakeri* by means of the chemoreceptor sensillae situated at the tip of its ovipositor.

Among torymids oviposition has been observed only in a few species. In *Syconscapteridea indica*, JOSEPH (1953) did not state whether this insect oviposited in ovaries of *Ficus* in which an agaonid had already oviposited or not. ANSARI (1966) claimed that in *Parakoebelia stratheni*, the eggs are laid in those ovaries in which no eggs of any fig wasps are already laid. Observations on *Philotryperis caricae* (JOSEPH, 1958) and the present studies on



A. bakeri : The egg, larval and prepupal stages. Fig. 1. The egg from the ovary of the female before oviposition; Fig. 2. The egg from the *Ficus* ovary (after deposition); Fig. 3. Section of the *Ficus* ovary showing the location of the parasite and host eggs; Fig. 4. First stage larva; Fig. 5. Mouth parts of the first stage larva; Fig. 6. Second stage larva; 7. Mouthparts of the second stage larva; Fig. 8. Prepupa. Abbreviations used : ap–the egg of *C. bakeri*; cer–the egg of *C. marchali*; epi cre–epicranial crest; lab–labium; labr–labrum; md–mandible; mx–maxilla; mp–mouthparts; ov. w–ovarian wall; ped–peduncle; st–style; v. l. pr–ventro-lateral prominences.



A. bakeri: Pupal stages. Fig. 9. 'White pupa' of the female; Fig. 10. 'White pupa' of the male; Fig. 11. 'Brown pupa' of the male; Fig. 12. 'Brown pupa' of the male; Fig. 13. Adult female (lateral view); Fig. 14. Adult male (lateral view).

Apocrypta bakeri show that the oviposition in a particular ovary by these torymid fig wasps is dependent on: 1. the presence in that ovary of the egg deposited by the respective agaonid host, and 2. the presence of the poison injected into the ovary during oviposition by the agaonid host itself. The second factor is found to be responsible for exciting the cells of the endosperm of *Ficus* ovary to divide repeatedly transforming it into a gall furnishing food for the larval stages. In these torymids the poison glands are atrophied probably because of the dependence of these insects on the poison injected by its host *(Ceratosolen)* for transforming the endosperm of the *Ficus* ovary into a gall for providing food for its developing larva.

The egg, post-embryonic development and number of generations per year

The egg: Prior to its deposition, the egg (Fig. 1) is an elongated structure with two distinct portions separated by a constriction. After deposition inside the *Ficus* ovary the egg (Fig. 2) is smaller in size and does not possess the two distinct parts: it is located inside the nucellus usually away from the region of the style where *Ceratosolen* egg is present (Fig. 3).

Larval stages: The eggs take about seven to eight days to hatch into the first stage larva (Fig. 4), with mouth parts (Fig. 5) feebly developed. The larva actively feeds on the food material available in the *Ficus* ovary and after seven days' growth it moults into the second stage larva (Fig. 6). The mouth parts (Fig. 7) now are fully developed with the characteristic features as shown in the figure.

Althogh both the host *(Ceratosolen)* and the parasite *(Apocrypta)* larvae develop into their respective second instars feeding on the available food in the *Ficus* ovary, later when the food material becomes depleted and competition becomes severe, the active parasite larva provided with sharp and pointed mandibles attacks and kills the host *Ceratosolen* larva and the cleptoperasite larva completes its development.

Prepupal stage : On completing a period of ten days growth, the larva moults to become prepupa (Fig. 8). It is an inactive stage lasting for eight to nine days before entering the pupal stage.

Pupal stages: Sexual dimorphism is distinguishable during the pupal stage, which shows two phases. The initial phase is the "white pupa" (Figs. 9 & 10) and the final one, the "brown pupa" (Figs. 11 & 12). The morphological changes that take place in these phases resemble those in *P. caricae* (JOSEPH, 1958). On the whole, the pupal stages take sixteen to eighteen days for completion. A final moult gives rise to the adults (Figs. 13 & 14).

The number of generations completed by the fig wasps–the parasite *A. bakeri* and its host *C. marchali*–corresponds to the number of fig crops for the year. Six distinct eclosions of *C. marchali* were already reported (ABDURAHIMAN & JOSEPH, 1976) and *A. bakeri* also correspondingly has six distinct generations per year, each generation requiring on an average of 53 days for completing the development from egg to adult stage.

REFERENCES

ABDURAHIMAN, U. C. & K. J. JOSEPH (1976) Observations on the Biology and Behaviour of *Ceratosolen marchali* MAYAR (Agaonidae, Chalcidoidea, Hymenoptera). *Entomon*, **1**: 115–121.

ANSARI, M. H. (1966) On a new species of fig insects (Chalcidoidea : Hymenoptera) from India. *Indian J. Ent.*, **28**: 74–83.

CONCI, G. (1924) Alcuni observazioni sul *'Ficus carica'* (L.) nel Trentino. *Boll. Chim. Far.* **10**: 6 pp.

GRANDI, G. (1921) Ricerche sul gen. *Philotrypesis* FORST. *Boll. Lab. Zool. Portici*, **15**: 33–190.

GRANDI, G. (1930) Monografia del gen. *Philotrypesis* Forst. *Boll. Lab. Ent. Inst. Sup. agr. Bologna*, **3**: 1–49.

JOSEPH, K. J. (1953) Contributions to our knowledge of fig insects (Chalcidoidea: parasitic Hymenoptera) from India. III. Descriptions of three new genera and five new species of Sycophagini, with notes on biology, distribution and evolution *Agra Univ. J. Res.*, **2** 67–69.

JOSEPH, K. J. (1958) Recherches sur les Chalcidiens *Blastophagapsenes* (L.) et *Philotrypesis caricae* (L.) du figuier *Ficus carrica* (L). *Annls. Sci. nat.*, **20**: 197–260.

LICHTENSTEIN, J. L. (1919) Note prliminaire au subjet de *Philotrypesis caricae* HASS. *Bull. Soc. ent. Fr.*,**17**: 313–316.

MAYER, P. (1882) Zur Naturgeschichte der Feigeninsekten. *Mitt. zool. Stn. Neapel*, **3B**: 551–590.

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HOST PREFERENCE AND HOST-BIOLOGY RELATIONS OF *CORCYRA CEPHALONICA* AND *EPHESTIA CAUTELLA*

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(*Received 30 September 1977*)

Comparative host preference of the rice moth, *Corcyra cephalonica* STAINT. and the almond moth, *Ephestia cautella* (WALKER) was studied on some of their common hosts, *viz.*, maize (*Zea mays* L.), wheat (*Triticum aestivum* L.), sorghum (*Sorghum vulgare* PERS.), rice (*Oryzae sativa* L.), and groundnut (*Arachis hypogeae* L.). The results showed that sorghum was the most preferred host for both the insects but per cent survival to pupal and adult stages for *C. cephalonica* were higher than *E. cautella*. The five hosts in the order of preference were : sorghum, maize, groundnut, rice and wheat for *C. cephalonica* and sorghum, maize, groundnut, wheat and rice for *E. cautella*.

(*Key words :* **host preference, host-biology relation,** *Corcyra cephalonica, Ephestia cautella*)

INTRODUCTION

The rice moth, *Corcyra cephalonica* STAINT, and almond moth, *Ephestia cautella* (WALKER), are serious lepidopterous pests of stored products. These polyphagous pests have a few common hosts, *viz.*, sorghum, maize, wheat, rice, beans (ATWAL, 1976), groundnut, sesamum (URS & MOOKHERJEE, 1966) and cottonseed (UBEROI, 1961). Many workers have studied the host preference of *C. cephalonica* (SUBRAMANIAM & RAO 1940; KRISHNAMURTI & RAO, 1945; RAO, 1954; UBEROI, 1961; JACOB *et al.*, 1966; PUNJ, 1967) and *E. cautella* (BURGES & HASKINS, 1965; KHARE *et al.*, 1966; URS & MUKHERJEE, 1966; GIRISH & PINGALE, 1968; MOOKHERJEE *et al.*, 1969; CHAUDHARI & BHATTACHARYA, 1976). The present work was undertaken to study the comparative host preference of *C. cephalonica* and *E. cautella* on some of their common hosts.

MATERIAL AND METHODS

The laboratory cultures of *C. cephalonica* and *E. cautella* were maintained respectively on broken sorghum and maize grains mixed with 5 per cent brewer's yearst, in 20×30 cm battery jars kept at 28±2°C and 75±5 per cent relative humidity with 12 hr illumination per day.

Four common cereals ie., maize, *Zea mays* L. (var. *Malan*), wheat, *Triticum aestivum* L. (var. *Kalyan sona*), sorghum, *Sorghum vulgare* PERS. (var. CSH 1), rice, *Oryzae sativa* L. (var. IR 8), and an oilseed groundnut, *Arachis hypogeae* L. var. *Samarala*, were selected for the growth study of these insects. The grains were kept at 60°C for 24 hr to avoid any hidden pest infestation. The sterilized grains were broken into small pieces of uniform size.

Freshly emerged moths from the laboratory culture were transferred to battery jars lined with blotting paper at the bottom for egg laying, and having 5 per cent sucrose solution in an injection vial fitted with a cotton wick for feeding. Sucrose solution was provided to increase the fecundity of moths (PAREEK & KUSHWAHA, 1971). Jars were wrapped with black paper to enable the moths to copulate. The eggs hatched in 4–5 days in case of *C. cephalonica* and 3–4 days in case of *E. cautella*. Twenty newly hatched larvae (within 24 hr) were transferred to ars containing 100 g of the food materials. The jars were kept in an incubator maintained at 28±2°C and 75±5 per cent RH. Each experiment had three replicates and the pooled data were evaluated by analysis of variance. The criteria used for deter mining host preference of the food materials were the larval and pupal durations, survival to pupal and adult stages, and pupal weight (2 day old).

RESULTS AND DISCUSSION

The data presented in Tables 1 and 2 revealed that sorghum was the most preferred host as the larvae of *C. cephalonica* and *E. cautella* reared on sorghum had higher per cent survival to pupa (100.00 and 91.67) and adult (93.33 and 86.67), higher pupal weights (28.17 mg and 11.51 mg for male, and 31.76 mg and 13.20 mg for female) and significantly faster development (26.92 days and 24.42 days for male, and 32.10 days and 26.78 days for female) to pupation. Similar results were obtained by SUBRAMANIAM & RAO (1940), and RAO (1954) for *C. cephalonica* and MOOKHERJEE *et al.* (1969) for *E. cautella*. However, CHAUDHARI & BHATTACHARYA (1976) reported that soybean, which was not included in the present study, supported the growth of *E. cautella* better than cereals and pulses. The least preferred among the five hosts tested was wheat for *C. cephalonica* and rice for *E. cautella* as there was significantly lower per cent survival to pupal and adult stages, less pupal weights and slower larval growth rate to pupation. The pupal durations varied very less as compared to larval durations on all the five hosts for both the insects. Similarly pupal duration for *Laphygma exigua* HB. (SRIVASTAVA, 1959) and *Argyrotaenia velutinana* (WALKER) (SHARMA *et al.*, 1972) remained almost unaffected when reared on different hosts, while significant differences were found in their larval durations.

There was significant difference in pupal weights of both the insect larvae fed on five different hosts (Tables 1 and 2). In case of *C. cephalonica*, the maximum weight was recorded on sorghum fed larvae while minimum on wheat fed; sorghum fed larvae also had maximum pupal weight in case of *E. cautella* but the minimum was recorded on rice-fed ones. The pupal weights for the

TABLE 1. Effect of hosts on biological features of *C. cephalonica*.

Host	Total larvae	Per cent survival to		Male (average)			Female (average)			Male : female ratio
		Pupa	Adult	Larval duration (days)	Pupal duration (days)	Pupal wt. (mg)	Larval duration (days)	Pupal duration (days)	Pupal wt. (mg)	
Sorghum	60	100.00a*	93.33a*	26.92a*	6.48a*	28.17a*	32.10a*	6.79a*	31.76a*	1 : 1.14
Maize	60	88.33b	81.67b	28.26a	6.46a	20.04b	33.17a	7.12a	22.65b	1 : 1.22
Groundnut	60	85.00c	81.67b	32.58b	6.48a	24.71c	40.20b	7.25a	27.30c	1 : 1.22
Rice	60	85.00c	80.00b	40.54c	6.38a	25.97d	43.89b	7.43a	28.52d	1 : 1.28
Wheat	60	31.67d	28.33c	41.50c	6.83a	11.08e	42.50b	8.55b	13.03e	1 : 2.33

*Values not followed by same letter are significantly different ($P < 0.05$).

TABLE 2. Effect of hosts on biological features of *E. cautella*.

Host	Total larvae	Per cent survival to		Male (average)			Female (average)			Male : female ratio
		Pupa	Adult	Larval duration (days)	Pupal duration (days)	Pupal wt. (mg)	Larval duration (days)	Pupal duration (days)	Pupal wt. (mg)	
Sorghum	60	91.67a*	86.67a*	24.42a*	7.89a*	11.51a*	26.78a*	7.85a*	13.20a*	1 : 1.75
Maize	60	81.67b	76.67b	26.12b	8.48b	10.38b	27.70a	8.99b	12.06b	1 : 1.45
Groundnut	60	80.00b	68.33c	30.22c	7.98a	9.34c	31.31b	7.97a	10.55c	1 : 1.15
Rice	60	28.33c	28.33d	36.67d	7.61a	5.21d	39.89c	8.77ab	6.19d	1 : 1.13
Wheat	60	43.33d	40.00e	34.80e	7.44a	6.15e	37.89c	9.00b	7.18e	1 : 1.00

*Values not followed by same letter are significantly different ($P < 0.05$).

remaining three hosts in descending order, were, maize, groundnut, rice for *C. cephalonica*, and maize, groundnut, wheat for *E. cautella*. As there is a direct positive correlation between nutritive value of foods and the pupal weights of insects raised on them (THOBBI, 1961; PAREEK & KUSHWAHA, 1971), the order of pupal weights of *C. cephalonica* and *E. cautella* on different hosts gave their respective nutritive value for the insects.

In general, for both the insects, females had lower growth rates and higher pupal weights on all the five hosts as compared to males. Similar observations were recorded on *Sitotroga cerealella* (OLIV.) (MILLS & WILBUR, 1967; CHIPPENDALE, 1971) and *A. velutinana* (SHARMA *et al.*, 1972), and was attributed to the inherent differences in male and female growth rates. For both the insects, females emerged in larger numbers on all the five hosts as compared to males. Interestingly, in *C. cephalonica* minimum male: female ratio (1 : 1.14) was observed on the most preferred host, sorghum and this ratio increased on lesser preferred hosts, the maximum being on wheat (1:2.33), the minimum preferred host; whereas almost reverse trend was observed in case of *E. cautella*.

The only criterion which can be taken into consideration while comparing the host preference of *C. cephalonica* and *E. cautella* on a single host is the survival to pupal and adult stages; the differences in others could be the result of variations in their respective life cycles. Sorghum, the most preferred host for both the insects supported *C. cephalonica* better than *E. cautella* as the survival of former to pupa (100.00%) and adult (93.33%) was higher as compared to the latter (91.67 and 86.67%). Similar observations were also noted in case of maize and groundnut, which were second and third in

order of preference for both the insects. Rice, which was the least preferred of all the hosts for *E. cautella* and had least larval survival to pupal and adult stages, had appreciably higher survival percentages (85.0 and 80.0) for *C. cephalonica*. Wheat which was the least preferred host of all the five host tested for *C. cephalonica* had slightly higher survival percentages for *E. cautella*.

Acknowledgements— The authors are grateful to the Head, Department of Entomology and the Dean, College of Agriculture, University of Udaipur for providing necessary facilities during the course of investigation.

REFERENCES

ATWAL, A. A. (1976) *Agricultural pests of India and South-east Asia*. Kalyani Publishers, Ludhiana, pp. 392–396.

BURGES, H. D. & K. P. F. HASKINS (1965) Life cycles of tropical warehouse moth, *Cadra cautella* WALKER, at controlled temperature and humidities. *Bull. ent. Res.*, **55** : 775–789.

CHAUDHARY, R. R. P. & A. K. BHATTACHARYA (1976) Larval developmental behaviour of *Ephestia cautella* (WALKER) on several food commodities. *Bull. Grain Tech.*, **14** : 3–8.

CHIPPENDALE, G. M. (1971) Growth and development of angoumois grain moth, *Sitotroga cerealella* in an artificial diet. *J. Insect Physiol.*, **17** : 109–115.

GIRISH, G. K. & S. V. PINGALE (1968) Ecology of stored grain insect pests. *Bull. Grain Tech.*, **4** : 76–95.

JACOB, A., N. M. DAS & M. R. G. K. NAIR (1966) Studies on the feeding media for mass rearing of *Corcyra cephalonica* STAINT. *Agric. Res. J. Kerala*, **4** : 82–85.

KHARE, R. N., R. N. K. MURTY & S. V. PINGALE (1966) Milling losses of food grain. Part–I. Studies on losses of redgram (*Cajanus cajan*) during milling. *Bull. Grain Tech.*, **4** : 125–132.

KRISHNAMURTHI, B. & D. S. RAO (1945) Alternate media for large scale rearing of the rice moth (*Corcyra cerphalonica* STAINT.) in the work of mass production of the egg parasite, *Trichogramma minutum* R. *Curr. Sci.*, **14** : 10.

MILLS, R. B. & D. A. WILBUR (1967) Radiographic studies of Angoumois grain moth development in wheat, corn, and sorghum kernels. *J. econ. Ent.*, **60** : 671–677.

MOOKHERJEE, P. B., B. N. BOSE & S. SINGH (1969) Some observations on the damage potential of the almond moth, *Cadra cautella* (WALKER) on eight different stored grains. *Indian J. Ent.*, **31** : 1–6.

PAREEK, B. L. & K. S. KUSHWAHA (1971) Biology and external morphology of forage pests. VIII. The cutworm, *Agrotis spinifera* HUBNER (Lepidoptera : Noctuidae). *Univ. Udaipur Res. J.*, **9** : 51–69.

PUNJ, G. K. (1967) Dietary efficiency of natural foods for the growth and development of *Tribolium castaneum* HERBST and *Corcyra cephalonica* STAINT. *Bull. Grain Tech.*, **5** : 209–213.

RAO, D. S. (1954) Notes on rice moth, *Corcyra cephalonica* STAINT. (Galleriidae : Lepidoptera). *Indian J. Ent.*, **16** : 95–114.

SHARMA, G. K., E. HODGSON & G. C. ROCK (1972) Nutrition and metabolism of sulphur amino acids in *Argyrotaenia velutinana* larvae. *J. Insect Physiol.*, **18** : 9–18.

SRIVASTAVA, B. K. (1959) Growth potential of *Laphygma exigua* HB. in relation to certain winter food plants. *Madras agric. J.*, **46** : 255–259.

SUBRAMANIAM, T. V. & D. S. RAO (1940) Biological control of sugarcane borers in Mysore. *Mysore Dept. agric. Ent. Bull.*, 12.

THOBBI, V. V. (1961) Growth potential of *Prodenia litura* F. in relation to certain food plants at Surat. *Indian J. Ent.*, **23** : 262–264.

UBEROI, N. K. (1961) Nutritional requirement of larvae of rice moth, *Corcyra cephalonica* STAINT. *Proc. Indian Acad. Sci.*, **53** : 284–297.

URS, K. C. D. & P. B. MOOKHERJEE (1966) Effect of oilseed food on the biology of *Tribolium castaneum* HERBST, *Trogoderma granarium* EVERTS and *Corcyra cephalonica* STAINT. and their susceptibility to pyrethrins. *Indian J. Ent.*, **28** : 234–240.

Entomon, 1978, *Vol.* 3, *No.* 1, *pp* 41 *to* 43

EFFECT OF YELLOW MOSAIC INFECTION OF THE HOST GREEN GRAM ON THE BIOLOGY OF *BEMISIA TABACI* (GENN.)

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(*Received 17 August 1977*)

Studies on the biology of the white fly vector *Bemisia tabaci* (GENN.) on healthy and yellow mosaic infected green gram leaves showed that oviposition by the vector was higher on infected than on healthy leaves. The incubation period of the egg, the duration of the second instar and puparium were also lower on the infected leaves than on the healthy leaves. The total life cycle of *B. tabaci* was completed in a shorter period on yellow mosaic infected leaves in comparison with the healthy leaves.

(*Key words* : **yellow mosaic infection, green gram, *Bemisia tabaci***)

INTRODUCTION

Green gram (*Phaseolus aureus* ROXB.) is one of the important pulse crops grown in India. NARIANI was the first to report the occurrence of yellow mosaic of mung in 1960 and established white fly *Bemisia tabaci* (GENN.) as the vector. Biology of the white fly *B. gossypiperda* (*B. tabaci*) was studied and reported by HUSSAIN & TREHAN (1933). Plant viruses have been shown to increase the reproductive capacity of insects and that the diseased plants can serve as better hosts for insects. RAGHURAMAN (1968) recorded a heavy infestation of *B. tabaci* on yellow vein mosaic infected bhendi plants. In this paper, the results of the experiments conducted to study the ovipositional preference and developmental periods of the vector *B. tabaci* both on healthy and yellow mosaic infected green gram plants are presented.

MATERIAL AND METHODS

CO 2 variety of green gram plants both healthy and yellow mosaic infected were used for oviposition and life history studies.

Oviposition

Two 10 day old green gram plants in one pot were taken for this experiment. The yellow mosaic disease was developed in one plant using the insect vector and the other plant was retained healthy. The tops of both the plants were nipped off retaining the second and third trifoliate leaves. These four trifoliates, two in healthy and two in diseased plants, were caged together in a glass chimney. Fifty non-viruliferous mated female adults of *B. tabaci* were released in the glass chimney. After a period of 72 hr the chimney and adults were removed and the number of eggs laid on each trifoliate counted under a stereozoom binocular microscope.

Incubation period

For studying the incubation period, mated females collected from the bulk population maintained in the glass house were transferred to healthy and infected plants separately, and allowed to oviposit. After 24 hr the adults were removed from the plant and the eggs laid were examined under stereozoom binocular microscope daily for hatching of the eggs.

Developmental periods

The mated females were collected from the bulk population and transferred to green gram plants for egg laying. The leaves were examined daily for hatching of the eggs. The nymphs emerged from the eggs were transferred to insect free healthy

and yellow mosaic infected plants in small pots with the help of a fine camel hair brush for individual life history studies. The development of the various nymphal stages was daily examined under stereozoom binocular microscope.

RESULTS AND DISCUSSION

Oviposition

Observations made on the fecundity of *B. tabaci* on healthy and yellow mosaic infected green gram plants which were caged together, indicated that the vector preferred the virus infected leaves over the healthy for oviposition. The mean number of eggs laid on yellow mosaic infected leaves was 77 as compared to only 14 eggs on healthy leaves. There was a significant increase of 420·0 per cent in oviposition by the vector on infected leaves over the healthy leaves.

Developmental periods

Mean incubation period of the egg and developmental periods of the various stages of *B. tabaci* on healthy and yellow mosaic infected green gram plants are presented in Table 1. Significant decrease in the duration of egg stage was observed in the case of eggs developing on infected plants. The mean duration was 6.5 days on healthy and 4.4 days on infected plants. Incubation period on infected plant was found to be decreased by 32.31 per cent over healthy.

Regarding the developmental period from first instar to adult, significant difference was noticed only in the first instar, the mean duration was 3.8 and 3.3 days on healthy and infected plants respectively. The duration of the first instar on infected plant decreased by 13.16 per cent. Though no significant difference in the developmental period of second and third instar and puparium was observed when developed on healthy or infected plant, the duration of second instar and puparium was low when developed on infected plant compared to those developed on healthy plant.

The mean total life cycle from egg to adult emergence was 24.7 and 21.5 days on healthy and infected plants respectively. Highly significant decrease (12.96 per cent) in the total life cycle of *B. tabaci*, developed on infected plant, was observed.

TABLE 1. Mean developmental periods of various stages of *B. tabaci* on healthy and infected green gram plants.

Developmental stage	Number of days		'F' test
	Healthy	Infected	
Egg stage	6.5	4.4 (-32.31)	**
First instar	3.8	3.3 (-13.16)	*
Second instar	3.4	3.3	NS
Third instar	3.0	3.4	NS
Puparium	8.0	7.1	NS
Total developmental period from egg to adult	24.7	21.5 (-12.96)	**

Figures in parentheses represent the percentage decrease over healthy.

** Significant at P=0.01%.
* Significant at P=0.05%.
NS Not significant.

The preference of white flies for oviposition on yellow colour was reported by several earlier workers (LLOYD, 1922; HUSSAIN & TREHAN, 1933; TREHAN, 1944; MOUND, 1962). SELLAMMAL MURUGESAN (1975) reported that consequent on virus infection, the concentration of chlorophyll was found to be lower in the yellow mosaic infected leaves compared to healthy leaves resulting in apparent change in the colour of foliage from green to yellow. Increased oviposition of *B. tabaci* on the infected leaf tissue might be attributed to the changed colour of foliage from green to yellow due to virus infection. The yellow coloured leaves in yellow mosaic infected green gram

plants resulted in increased attraction of *B. tabaci* and consequently increased oviposition.

The incubation period of the egg and the total life cycle of *B. tabaci* were significantly low in virus infected compared to the healthy leaves. These findings are in conformity with the results of RAGHURAMAN (1968) with *B. tabaci* and yellow vein mosaic infected bhendi. Increased quantities of sugars, total nitrogen, protein and phosphorus in the yellow mosaic infected tissue of green gram have been reported by SELLAMMAL MURUGESAN (1975) and there are reports relating to higher preference of insect pests to plant tissues possessing higher concentration of sugars, total nitrogen and phosphorus (LAPIDUS *et al.*, 1963: KNAPP *et al.*, 1966; KALODE & PANT, 1967; RAJAGOPAL, 1968; THEVASAKAYAM, 1962; UTHAMASAMY, 1969; CHELLIAH, 1971). The infected leaf tissue was highly conducive for the development of the white fly and large population of adults would develop in a comparatively shorter period. The preference for oviposition and survival of the white fly may be due to the change in biochemical constitution of the virus infected plant which would have been very conducive to the vector *B. tabaci*.

Acknowledgement:— The senior author is thankful to Tamil Nadu Agricultural University, Coimbatore for according permission to publish this research finding which formed part of a dissertation submitted to the award of M. Sc. (Ag.) degree.

REFERENCES

CHELLIAH, S. (1971) Some investigations in musk melons and *Cucumis callosus* (ROTTL.) cogniaux on resistance to the fruit fly *Dacus cucurbitae* COQUILLETT (Diptera, Tephretidae). Doctoral Thesis, Annamalai University.

HUSSAIN, M. A. & K. N. TREHAN (1933) Observations on the life history, bionomics and control of the white fly of cotton (*Bemisia gossypiperda* (M. & L.). *Indian J. agric. Sci.*, **3** : 701–753.

KALODE, M. B. & N. C. PANT (1967) Studies on the amino acids, nitrogen, sugar and moisture content of maize and sorghum varieties and their relation to *Chilo zonellus* (SWIN.) resistance. *Indian J. Ent.*, **29** : 139–144.

KNAPP, J. L., P. A. HEDIN & W. A. DOUGLAS (1966) A chemical analysis of corn silk from single crosses of Dent corn rated as resistant, intermediate and susceptible to the corn ear worm. *J. econ. Ent.*, **59** : 1062–1064.

LA PIDUS, J. B., R. W. CLEARY, R. H. DAVIDSON, F. W. FISK & M. G. AUGUSTINE (1963) Chemical factors influencing host selection by the Mexican bean beetle, *Epilachna varivestis* MULS. *J. agric. Fd. Chem.*, **11** : 462–463.

LLOYD, L. L. (1922) The control of the green house white fly (*Asterochiton vaporariorum*) with notes on its biology. *Ann. appl. Biol.*, **9** : 1–32.

MOUND, L. A. (1962) Studies on the olfaction and colour sensitivity of *Bemisia tabaci* (GENN.). *Entomologia expt. Appl.*, **5** : 99–104.

NARIANI, T. K. (1960) Yellow mosaic of mung (*Phaseolus aureus*). *Indian Phytopath.*, **13** : 24–29.

RAGHURAMAN, T. V. (1968) Preference of the aleyrodid (*Bemisia tabaci* (GENN.) for bhendi plants infected with yellow vein mosaic virus with particular reference to the biochemical mechanisms. M. Sc. (Ag.) Dissertation, Univ. of Madras.

RAJAGOPAL, K. (1968) Studies on the resistance of jasmine varieties to the Eriophyid mite, *Aceria jasmini* C. (Eriophyidae : Acarina). M. Sc. (Ag.) Dissertation, Univ. of Madras.

SELLAMMAL MURUGESAN (1975) Studies on the relationship of the vector, *Bemisia tabaci* (GENNADIUS) (Homoptera, Aleyrodidae) with the yellow mosaic virus of green gram (*Phaseolus aureus* ROXB.). M. Sc. (Ag.) Dissertation, Tamil Nadu Agricultural University, Coimbatore.

THEVASAKAYAM, E. S. (1962) Observations on the relative susceptibility of three varieties of cotton to *Aphis gossypii* G. *Trop. Agric., Manila*, **117** : 101–104.

TREHAN, K. N. (1944) Further studies on the bionomics of *B. gossypiperda*, the white fly of cotton in Punjab. *Indian J. agric. Sci.*, **14**: 53–63.

UTHAMASAMY, S. (1969) Studies on the varietal resistance of bhendi (*Abelmoschus esculentus* (L.) MOENCH) to the leaf hopper *Amrasca devastans* DIST. (Homoptera: Jassidae). (M. Sc. Ag.) Dissertation, Univ. of Madras.

Entomon, 1978, *Vol.* 3, *No.* 1, *pp.* 45 *to* 49

ECONOMICS OF MASS REARING OF *TRICHOGRAMMA BRASILIENSIS* ASHMEAD (HYMENOPTERA : TRICHOGRAMMATIDAE)

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Investigations were carried out on the economics of mass rearing of *Trichogramma brasiliensis* which involved the mass rearing of its laboratory host *Corcyra cephalonica* STAINTON. The average number of host adults which emerged from one kg of diet each initially inoculated with 2700 and 1350 *Corcyra* eggs was 1143.3 and 890.0 respectively. The total egg production was found to be 3773 mg (1, 01, 871 eggs) for 890.0 adults while for 1134.3 adults it was 3634.3 mg (98, 126 eggs). The total number of host eggs produced during 2 months was 6, 00, 000 and the total number of parasites produced was 5, 88, 120. The calculated cost of production of 1000 parasites was Rs 1.10.

(*Key words* : **economics, mass rearing, *Trichgramma brasiliensis*)**

INTRODUCTION

The genus *Trichogramma* was established by WESTWOOD (1833) and has more than 150 host species in the different orders of insects viz., Lepidoptera, Coleoptera, Hymenoptera, Neuroptera, Diptera and Hemiptera(MARTIN, 1928). *Trichogramma* has been extensively mass reared and mass released in Mexico, Peru, USSR and Bulgaria against lepidopterous pests and in India it has been released against sugarcane borers and cotton boll worms with varying degrees of success (SANKARAN, 1974). Since *T. brasiliensis* is a thelytokous species its mass rearing will be more economical and its mass release would result in better control than that of some other species of *Trichogramma*. The prerequisite for mass release is the production of large numbers of parasites at low cost. Therefore, studies on the economics of mass rearing *T. brasiliensis* employing improved techniques of cost analysis were undertaken.

MATERIALS AND METHODS

Rearing of *C. cephalonica* : crushed 'jowar' containing yeast at the rate of 5 g per kg was used as diet. *Corcyra* eggs were uniformly spread on the diet surface layer after layer in glass jars (20×15 cm). Rearing jars covered with marking cloth were kept at room temperature of 27±2° C. After emergence the moths were released in oviposition cages, made of glass jars (20×15 cm) cut at the bottom end. The two open ends were covered with wire gauze and the bottom end of the cut jar was used for collection of eggs. The normal developmental period from egg to egg at 27±2°C was found to be 46–50 days.

Rearing of *T. brasiliensis* : The culture initiated with a single parasitized host egg was further built up by release of about 80 parasites in each rearing glass tube (10×5 cm) containing approximately 2400 host eggs pasted on egg cards with gum arabic (5 per cent). The culture was maintained in a desiccator under controlled relative humidity of 70±3 per cent and temperature 27±2° C.

RESULTS

Host production: The results of host production under laboratory conditions are given in Table 1. At two initial levels of egg density with diet and space as constant factors, out of 2700 eggs on an average 1134.3 moths emerged with an average egg production of 3634.3 mg while in case of 1350 eggs per kg of diet the average moth

TABLE 1. Adult emergence and egg production of *C. cephalonica* at two initial levels of egg density per kg of diet.

Replication	2700 eggs per kg diet		1350 eggs per kg diet	
	Adult emergence	Egg production (mg)	Adult emergence	Egg production (mg)
I	1104	4151	867	3833
II	1108	3578	866	3574
III	1191	3174	938	3912
Mean	1134.3	3634.3	890	3773

TABLE 2. Laboratory mass rearing of *T. brasiliensis*.

Sl. No.	No. of parasites released (females + males)*	No. of blackened/ parasitized eggs	No. of adults emerged	per cent " wastage " due to non-emergence	Fecundity per female parasite
1.	120 (72)	3070	2998	2.35	43
2.	105 (63)	3541	3449	2.60	56
3.	123 (74)	3857	3857	0.00	52
4.	195 (117)	4765	4625	2.94	41
5.	183 (110)	4722	4651	1.55	43
6.	215 (129)	4836	4717	2.46	37
Mean	157 (94)	4132	4049	1.98	45

Figures in parentheses indicate the number of female parasites.
* Males are produced in *T. barsiliensis* when temperature of rearing room rises above 30°C.

emergence was found to be 890 with an average egg production of 3773 mg.

Parasite production: The results obtained from mass rearing of the parasite have been summarized in Table 2. The experiment was conducted at the prevailing room temperature which was found to rise above 30°C. Sex ratio in a lot of samples examined was 3 ♀ ♀ : 2 ♂ ♂. It is seen from Table 2 that in mass rearing the fecundity of a single parasite was 45. The "wastage" due to non-emergence of adult parasites from blackened/ parasitized eggs was found to vary from 0–3 per cent.

The cost of mass production of the parasite was worked out on the basis of materials used for the production of host eggs and parasites which also included permanent costly equipment like air conditioner and other electrical appliances and their operating

cost The calculated labour cost is actual as the present investigators have actually handled all the operations concerning host egg production and parasite production. The cost of mass production is presented below :

		Rs. Ps.
A.	*Fixed cost*	
1.	Total cost of permanent equipment installed in the laboratory.	4534.35@
	(a) Depreciation x, y at the rate of 20 per cent per annum.	1.81
	(b) Interest x, y over the capital at the rate of 7 per cent per annum.	0.64
2.	Total cost of other permanent equipment used.	255.50
	(a) Depreciation x, y at the rate of 20 per cent per annum.	8.52
	(b) Interest x, y over the capital at the rate of 7 per cent per annum.	2.98
3.	Room rent at x, y at the rate of Rs 50/- per month.	1.20
B.	*Variable cost*	
1.	Total cost of conusmable articles actually used.	29.06
2.	* Electricity charges x, y	5.30
3.	Labour charges y	600 .00
	Calculation	
	Fixed cost A : I (a+b)+2 (a+b)+3	15.15
	Variable cost B ; 1+2+3 Rs.	634.36
	Total Rs.	649.51
	Total number of host eggs produced from six jars in 2 months	6,00,000
	" Wastage " (Number of parasitized eggs which failed to produce adults) at the rate of 1.98 per cent.	11, 880
	Number of parasites reared from 6, 00, 000 host eggs.	5, 88, 120
	Therefore cost of production of 5, 88, 120 parasites	Rs. 649.51
	Cost of production of 1,000 parasites (600 females and 400 males)	Rs. 1.10

(x = Calculated for 6 jars ; y = claculated for two months : * = Calculated on the basis of Delhi Electric Supply Undertaking rates ; and @ = Permanent equipment installed include one air conditioner, one fan, two tube lights and a table lamp cost of which has been accounted at 1971 rates.)

The total number of host eggs produced from 6 jars was 5,99,994 which is rounded off to 6,00,000 for calculation purposes. Here the labour charges were calculated on the basis of one parasite breeder for 6 jars of the host for a period of two months. Taking into consideration the "wastage," the actual amount spent for 5,88,120 parasites was Rs 649.51. Cost of production per 1,000 *T. brasiliensis* under controlled conditions in the laboratory was found to be Rs 1.10.

DISCUSSION

The economics of mass production of various parasites has been the object of study of numerous workers. In all such studies with parasites different method of analysis have been employed. FINNEY *et al.* (1947) worked out the cost of production of *Macrocentrus* sp. from several different angles and found that 1,000 parasites could be produced at a cost of 78 cents. This cost did not include freight of potatoes, depreciation on buildings, equipment, and supplies of cardboard and sand. SCOPES (1968, 1969) worked out the cost of producing *Encarsia formosa* GAHAN a parasite of the white fly, *Trialeurodes vaporariorum* WESTWOOD but he considered the life of equipment

used as 10 years for working out the economics of mass rearing. PURI & SANGWAN (1972) calculated the economics of mass rearing of *Bracon gelechiae* ASHMEAD on the basis of expenditure on permanent equipment, labour charges and the consumable articles used. They have not included the operational charges, the building rent, etc. Their listing of equipment did not include costly equipment like air conditioner, fans and tube light which are normally required for host as well as parasite rearing under Delhi conditions.

SPENCER *et al.* (1935) worked out the economics of mass rearing of *Trichogramma minutum* RILEY taking into account the cost of all equipment used at the rate of 10 per cent depreciation per annum. They included fuel, gas and electricity charges, the actual cost of glasswere and miscellaneous supplies and food (for rearing host). The labour charges were calculated in days on hourly basis for moth collection, cleaning of the eggs, pasting eggs, parasite propagation, cleaning of glassware and screening of dirty corn. This work was taken as a model and the present calculations were made accordingly. The major equipment provided in the laboratory–their total cost was calculated taking into consideration the total life of equipment as 5 years and the interest over the capital at the rate of 7 per cent per annum. The labour charges were not divided on hourly basis but on the actual period of work i. e., covering the period of host emergence and the production of eggs. The cost were put under the following heads :

(A) A Fixed cost and (B) Variable cost. The cost worked out with respect to variable cost is actual. The experimental period lasted for two months and so the depreciation and interest were calculated for this period only. The experiments were conducted is a room 4.27 × 3.05 metres with six host rearing jars. It was assumed that the above room had the capacity to hold a minimum of 500 jars. Therefore, the cost of installed equipment, room rent and electricity charges were converted for six jars.

An analysis of the cost of production of parasites revealed that in all such experiments the major input is the labour cost (TUCKER, 1930; SPENCER *et al.*, 1935). PURI & SANGWAN (1972) also quoted a labour charge of Rs 300 out of a total cost of Rs 357.23 for the monthly production of 2,29,680 eggs of *B. gelechiae*. Likewise, in the present investigation the major expenditure in the cost of production was that of labour charges amounting to Rs 600 out of a total of Rs 649.51. The major input which accounted for a total production of 5,88 120 parasites has been included under variable cost since the labour charges vary, often depending upon the cost index. The labour involved in the rearing of insects cannot be mechanised and therefore the labour charges cannot be reduced any further. In the present investigation the actual work done by the investigator for two months was directly considered for the calculation of the production cost. The investigator could have handled 6 more *Corcyra* rearing jars during the same period and thereby produced 5,88120 more parasites at a very little additional cost. The cost of production of a thousand parasites would have then been slightly above Re 0.55.

In an uniparental species like *T. brasiliensis* the production cost normally pertains to production of females only but in the present investigations as the temperature increased the production of male parasites was observed to the extent of 40 per cent. FLANDERS & QUEDNAU (1960) also noticed 50 per cent males in culture as the rearing temperature approached 32° C. Hence the

production cost worked out for 1,000 parasites in the present investigations includes both females and males.

REFERENCES

FINNEY, G.L., S,E. FLANDERS, & H.S. SMITH (1947) Mass culture of *Macrocentrus ancylivorus* ROHWER and its host, the potato tuber moth. *Hilgardia*, **17** : 437–483.

*FLANDERS, S.E. & W. QUEDNAU (1960) Taxonomy of the genus *Trichogramma* (Hymenoptera, Chalcidoidea, Trichogrammatidae). *Entomophaga*, **5** : 285–294.

*MARTIN, C. H. (1928) Biological studies of two hymenopterous parasites of aquatic insect eggs. *Entomologica am.*, **8** : 105–131.

PURI, S.N. & H.S. SANGWAN (1972) Economics of mass rearing of *Bracon gelechiae* ASHMEAD. *Indian J. Ent.*, **34** : 232–239.

SANKARAN, T. (1974) Natural enemies introduced in recent years for biological control of agricultural pests in India. *Indian J.agric. Sci.*, **44** : 425–433.

SCOPES, N. E. A. (1968) Mass rearing of *Phytoseiulus riegeii* D. for use in commercial horticulture. *Pl. Path.*, **17** : 123–126.

SCOPES, N.E.A. (1969) The economics of mass rearing of *Encarsia formosa* GAHAN, a parasite of whitefly, *Trialeurodes vaporariorum* WESTWOOD for use in commercial horticulture. *Pl. Path.*, **18** : 130–132.

SPENCER, H., L. BROWN & A.M. PHILIPS (1935) New equipment for obtaining host material for the mass production of *Trichogramma minutum* RILEY, an egg parasite of various insect pests. *U.S. Dept. Agric. Circ.*, 376, 17 pp.

TUCKER, R. W. E. (1930) The mass breeding of *Trichogramma minutum* RILEY to control *Diatraea saccharalis* (FABRICIUS) in Barbados during 1930. *Trop. Agric. Trin.*, **8** : 283–288.

*WESTWOOD, J. O. (1833) Description of several new British forms amongst the parasitic hymenopterous insects. *The London* and *Edinburgh Philosophical Magazine and Journal of Science* **2** : 444.

* Original not seen.

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COMPARATIVE EFFICACY AND RELATIVE RESIDUAL TOXICITY OF SOME INSECTICIDES TO THE CITRUS BUTTERFLY CATERPILLAR, *PAPILIO DEMOLEUS* LINNAEUS (PAPILIONIDAE : LEPIDOPTERA)[1]

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(*Received 23 August 1977*)

In field and field cum laboratory studies, seventeen insecticides were evaluated against the caterpillars of Citrus butterfly, *Papilio demoleus* (LINNAEUS) on Italian lemon. Although eight of the insecticides gave highly effective control under field conditions yet, except methyl parathion (0.05%), methamidophos (0.05%) and leptophos (0.06%), all other insecticides had lesser residual action.

(*Key words* : **efficacy, toxicity, insecticides, *Papilio demoleus***)

INTRODUCTION

Among leaf eating caterpillars attacking citrus in India, citrus butterfly, *Papilio demoleus* (LINNAEUS) is the most serious and widespread pest. In Kodagu, this butterfly has been recorded as a serious pest of nurseries, young plants and tender flushes of old trees. The age old practice of the control of this pest by hand picking and destruction of caterpillars and pupae still holds good in small areas, or in areas with low pest population. But in case of pest outbreak chemical control becomes necessary. ABRAHAM (1957) recommended the use of malathion (0.03%), BHC (0.05%) and ethyl parathion (0.025%) for most effective and economical control of this pest. SETHI (1965) reported that parathion (0.02%) was most effective insecticide followed in descending order by fenitrothion (0.02%), endrin (0.025%), diazinon (0.02%) and DDT (0.1%) against fourth and fifth instar caterpillars. Three spray schedule of carbaryl (0.2%) at fifteen days interval was also found to be effective (SHARMA & SRIVASTAVA, 1970). Under laboratory conditions mevinphos (0.01%), parathion (0.025%) and malathion (0.05%) gave successful control (SAINI & SHARMA, 1970). In the present investigations detailed studies have been made to assess the potential of some insecticides for the control of this pest.

MATERIALS AND METHODS

The insecticides were evaluated under field conditions and to find out their residual toxicity field cum laboratory tests were conducted.

Field experiment was conducted in November 1976 on three year old Italian lemon plants in randomized block design. Each treatment was replicated four times, assigning single tree per treatment. Treatments comprised of seventeen contact insecticides and a control (Table 1). Spraying was done once and each tree was sprayed with one litre of spray fluid and the control plants were sprayed with water. To determine the comparative efficacy of various insecticides initial population of caterpillars (most of the caterpillars were in their 3rd or 4th instar) were counted on each tree in all the treatments. Then the insecticides were sprayed at the specified concentrations as indicated in Table 1. After 1,3,7 and 10 days of spray, counts were taken on alive caterpillars and at each count dead caterpillars were removed from the treatmental plants.

[1] Contribution No. 570 of the Indian Institute of Horticultural Research, Bangalore-6.

From 7th day after spray apart from the count on alive caterpillars, fresh infestation on new flushes was also noted. The percentage mortalities were calculated and the figures thus obtained were transformed into angular values and the data were statistically analysed. The results are presented in Table 1.

A laboratory cum field trial was also conducted simultaneously to determine the residual toxicity of the seventeen contact insecticides at the specified concentrations (Table 2). The insecticides were sprayed in the field using randomized block design having four replications in each treatment. Control plants were sprayed with water. For studying the relative residual toxicity, leaf samples were collected from different treatments. First sample was collected from the field two hours after spraying and subsequent samples were collected at 24 hr interval till the toxic effect of the most of the chemicals disappeared. The leaves were kept in 1 litre capacity glass jars containing a layer of sand covered with blotting paper at the bottom to absorb extra moisture. The mouth of the jar was covered with muslin cloth with the help of rubber bands. The 3rd stage caterpillars were released in each replication jar. Each such jar containing treatmental leaves and ten caterpillars was then kept at room temperature for 48 hours and mortality counts were taken after 24 and 48 hours. Thus leaf samples collected daily were kept under observation for a period of 48 hours and every day the dead caterpillars were discarded. But the first set of caterpillars which were fed on the leaves collected just after 2 hours of spraying were kept as such for 48 hours and mortality counts were taken on 24 hours and 48 hours after that the survivals were reared in the laboratory on new healthy fresh leaves till they pupated. The pupae were transferred to cages where observations were recorded on the pupal mortality and adult emergence and data are presented in Table 3. For finding out the relative persistence of different insecticides, PT index method suggested by PRADHAN & VENKATARAMAN (1962) was used in analysis and the data are presented in Table 2.

During the course of field investigations average maximum and minimum temperatures were 26.3°C and 17.5°C, average relative humidity was 84% and the rainfall was 86.5 mm with 9 rainy days. In the laboratory the average maximum and minimum temperatures were 30.3°C and 15.4°C and the relative humidity was 86.5%.

RESULTS AND DISCUSSION

(i) Field trial

Table 1 gives the percentage reduction in population at different intervals (in days) after spraying in different treatments. It may be observed that on first day after spraying quinalphos, leptophos, methyl parathion, methomyl and methamidophos gave complete kill of caterpillars. Fenitrothion, carbaryl and endosulfan were at par with the above treatments by giving an effective kill of 98.5, 98.1 and 92.5% respectively.

On 3rd day carbaryl also gave 100% kill of caterpillars. At this stage quinalphos, leptophos, methyl parathion, methomyl, methamidophos, carbaryl, fenitrothion, endosulfan and malathion were on par with one another. Only in case of BHC and chlorfenvinphos there was slight reduction in per cent mortality while in other cases there was an increase in mortality.

On 7th day of observation, fenitrothion and endosulfan also gave complete control of this pest. Trichlorfan, phenthoate and phosalone gave an effective kill of 95.0%, 92.2% and 89.25% respectively and were at par with other treatments. There was a reduction in efficacy in case of phenthoate, mixture of malathion + fenitrothion (Ambithion), malathion, fenthion and dioxathion. In case of BHC and chlorfenvinphos treated plants reinfestation of small caterpillars was observed.

On 10th day of observation reinfestation of newly hatched caterpillars was observed in all the treatments except in leptophos treated plants. Thus, it was found that under field conditions quinalphos, leptophos, methyl parathion, methomyl, methamidophos, carbaryl, fenitrothion and endosulfan were found to be the best insecticides for controlling this pest.

TABLE 1. Efficacy of various insecticides against *Papilio demoleus* (L.) under field conditions.

Name of the insecticide		Concentration (%)	Percentage reduction in population of caterpillars after days*							
			1		3		7		10	
Quinalphos	(Ekalux 25 E C)	0.05	100.00	(90.00)	100.00	(90.00)	100.00	(90.00)	..	
Fenitrothion	(Folithion 50 E C)	0.05	98.5	(82.96)	98.5	(82.96	100.00	(90.00)	..	
Endosulfan	(Thiodan 35 E C)	0.05	92.5	(74.11)	97.5	(80.90)	100.00	(90.00)	..	
Leptophos	(Phosvel 34 E C)	0.06	100.00	(90.00)	100.00	(90.00)	100.00	(90.00)	100.00	(90.00)
Malathion+ Fenitrothion	(Ambithion 50 EC)	0.05	85.5	(67.62)	88.9	(70.54)	77.98	(61.89)		
Phenthoate	(Phendal 50 E C)	0.05	87.0	(68.87)	93.1	(74.77)	92.22	(73.78)	..	
Phosalone	(Zolone 35 E C)	0.05	66.3	(54.51)	84.6	(66.89)	89.25	(70.91)	..	
Trichlorfon	(Dipterex 50 E C)	0.05	86.9	(68.78)	91.9	(73.46)	95.00	(77.08)	..	
Malathion	(Malathion 50 E C)	0.05	89.6	(71.19)	96.0	(78.46)	83.33	(65.88)	..	
Fenthion	(Lebaycid 100 E C)	0.05	68.6	(55.92)	69.9	(56.73)	64.30	(53.31)	..	
Methyl parathion	(Metacid 50 E C)	0.05	100.00	(90.00)	100.00	(90.00)	100.00	(90.00	..	
Methomyl	(Lannate 90 S P)	0.05	100.00	(90.00)	100.00	(90.00)	100.00	(90.00)	..	
Carbaryl	(Sevin 50 W P)	0.1	98.1	(82.08)	100.00	(90.00)	100.00	(90.00)	..	
B H C	(BHC 50 W P)	0.1	89.9	(71.47)	79.8	(63.29)	..	..	..	
Chlorfenvinphos	(Birlane 24 E C)	0.05	57.6	(49.37)	35.9	(36.81)	..	..	..	
Dioxathion	(Delnav 33 E C)	0.05	24.1	(29.40)	50.4	(45.23)	36.18	(36.99)	..	
Methamidophos	(Monitor 50 E C)	0.05	100.00	(90.00)	100.00	(90.00)	100.00	(90.00)	..	
Control	(Water spray)		(0.00)	0.00	(0.00)	0.00	(0.00)	(0.00)	..	
C D (P=0.05)				(17.74)		(15.01)		(20.93)	..	

* Average of four replications.

.. Reinfestation started on new flushes and no further mortality.
Figures in parentheses are the mean angular values.

TABLE 2. Relative residual toxicity of various insecticides against *Papilio demoleus* (L).

Name of the insecticides	Concentration (%)	Mortality on the day (%)					
		First	Last	X	T	P	PT
Quinalphos (Ekalux 25 E C)	0.05	52.5	2.5	2	24.7	9	222.3
Fenitrothion (Folithion 50 E C)	0.05	47.5	2 5	0	16.7	6	100.2
Endosulfan (Thiodan 35 E C)	0.05	90.0	5.0	1	30.4	7	212.8
Malathion+Fenitrothion (Ambithion 50 E C)	0.05	25.0	15.0	0	13.8	7	96.6
Phenthoate (Phendal 50 E C)	0.05	27.5	2.5	0	10.7	7	74.9
Phosalone (Zolone 35 E C)	0.05	45.0	12.5	1	31.1	9	279.9
Trichlorfon (Dipterex 50 E C)	0.05	55.0	5.0	1	16.9	4	67.6
Malathion (Malathion 50 E C)	0.05	22.5	7.5	0	11.7	6	70.2
Fenthion (Labaycid 100 E C)	0.05	20.0	5.0	0	11.7	3	35.1
Methyl parathion (Metacid 50 E C)	0.05	95.0	5.0	8	47.9	17	814.3
Methomyl (Lannate 90 S P)	0.05	90.0	5.0	2	22.1	6	192.9
Carbaryl (Sevin 50 W P)	0. 1	75.0	5.0	1	29.2	6	175.2
BHC (BHC 50 W P)	0. 1	40.0	5.0	0	18.3	3	54.9
Chlorfenvinphos (Birlane 24 E C)	0.05	10.0	10.0	0	10.0	2	20.0
Leptophos (Phosvel 34 E C)	0.06	100.0	22.5	6	58.9	9	530.1
Dioxathion (Delnav 33 E C)	0.05	55.0	10.0	1	28.3	3	84.9
Methamidophos (Monitor 50 E C)	0.05	100.0	5.0	12	61.6	16	985.6

X = Period in days upto which at least 50% mortality was observed.
T = Average per cent mortality per day.
P = Period in which some mortality was observed and
PT = Residual toxicity index.

TABLE 3. After-effects of various insecticidal treatments on the development of *Papilio demoleus* (L.).

Name of the insecticide	Concentration %	Total no. of caterpillars released in 4 replications.	Mortality of caterpillars after days										Total no. of caterpillars dead	No. of caterpillars pupated	No. of adults emerged	
			1	2	3	4	5	6	7	8	9	10			With well-developed wings	With deformed wings.
Quinalphos (Ekalux 25 E C)	0.05	40	14	3	4	1	0	1	4	0	0	1	28	12	12	0
Fenitrothion (Folithion 50 E C)	0.05	40	10	9	0	1	0	0	3	0	0	0	23	17	16	1
Endosulfan (Thiodan 35 E C)	0.05	40	22	4	2	2	4	0	0	0	2	0	36	4	1	3
Leptophos (Phosvel 34 E C)	0.06	40	38	2	–	–	–	–	–	–	–	–	40	—	—	—
Malathion+Fenitrothion (Ambithion 50 E C)	0.05	40	7	3	0	0	1	0	2	0	0	1	14	26	21	5
Phenthoate (Phendal 50 E C)	0.05	40	8	3	0	0	2	0	0	0	2	3	18	22	19	3
Phosalone (Zolone 35 E C)	0.05	40	13	5	0	3	2	1	3	0	1	0	28	12	12	0
Trichlorfan (Dipterex 50 E C)	0.05	40	15	2	5	0	0	1	0	0	1	0	24	16	15	1
Malathion (Malathion (50 E C)	0.05	40	4	1	4	1	0	0	0	0	1	0	11	29	29	0
Fenthion (Lebaycid 100 E C)	0.05	40	6	2	0	0	2	0	0	2	0	2	14	26	21	5
Methyl parathion (Metacid 50 E C)	0.05	40	30	8	0	0	0	2	–	–	–	–	40	—	—	—
Methomyl (Lannate 90 S P)	0.05	40	34	0	2	0	0	2	0	0	0	0	38	2	—	2
Carbaryl (Sevin 50 W P)	0.1	40	20	8	4	4	0	0	0	0	0	0	36	4	3	1
BHC (BHC 50 W P)	0.1	40	4	10	2	2	0	0	0	0	0	2	20	20	18	2
Chlorfenvinphos (Birlane 24 E C)	0.05	40	4	0	0	0	0	0	0	0	2	2	8	32	28	4
Dioxathion (Delnav 33 E C)	0.05	40	12	6	4	2	4	0	2	0	2	2	34	6	6	0
Methamidophos (Monitor 50 E C)	0.05	40	36	2	2	–	–	–	–	–	–	–	40	—	—	—
Control (Water spray)	—	40	2	0	0	0	0	0	0	0	0	2	4	36	35	1

The caterpillars were allowed to feed on leaves for 48 hours after which fresh food was supplied. The mortality counts were taken at 24 hours interval.

Earlier, SETHI (1965) reported that parathion (0.02%) and fenitrothion (0.02%) were very effective insecticides against this pest. SHARMA & SHRIVASTAVA (1970) also found that carbaryl (0.2%) in three spray schedule at fifteen days interval was effective. In our studies also it was found that methyl parathion (0.05%), fenitrothion (0.05%) and carbaryl (0.1%) were effective apart from the other effective insecticides reported above.

(ii) *Field cum laboratory experiment for finding out the residual toxicity*

The results in Table 2 show that two hour old deposits of leptophos, and methamidophos caused 100% mortality of caterpillars, while in case of methyl parathion it gave 95% kill. Endosulfan and methomyl gave 90% kill. Due to the residual action methamidophos gave 100% mortality of caterpillars upto 3 days of spraying. The residues in leaves enough to kill 50% of caterpillars persisted for 12, 8 and 6 days in case of methamidophos, methyl parathion and leptophos respectively. The 'PT' index values of the most promising insecticides in descending order were methamidophos (985.6), methyl parathion (814.3), and leptophos (530.1). Thus these three insecticides were found to be the most persistent insecticides. Earlier SHARMA & SHRIVASTAVA (1970) reported that carbaryl (0.2%) at 15 days interval applied thrice given a satisfactory control. But our observations have shown that this insecticide even though has given a good control of this pest under field conditions, it had very low 'PT' index value of 175.2.

The data in Table 3 reveal that out of 40 released caterpillars in four replications all were dead in case of leptophos, methyl parathion, and methamidophos. In case of endosulfan treatment only four caterpillars survived. Methomyl treatment had two survivals. In both of these treatments percentage of adults emerged with deformed wings were more unlike in other treatments.

Thus, based on the results of these experiments methyl parathion (0.05%), methamidophos (0.05%) and leptophos (0.06%) were found to be the most persistent and effective insecticides for the control of *Papilio demoleus* (LINNAEUS).

Acknowledgements :—The authros are thankful to Dr. G. S. RANDHAWA, Director, Indian Institute of Horticultural Research, Bangalore and Mr. K. M. GANAPATHY, Horticulturist, Horticultural Experiment Station, Chethalli for providing necessary facilities and to Dr. V.G. PRASAD, Head, Division of Entomology, for his keen interest in these studies.

REFERENCES

ABRAHAM, E. V. (1957) A note on the control of the citrus butterfly, *Papilio demoleus* L. *South Indian Hort.*, **5** : 25–29.

PRADHAN, S & T. V. VENKATARAMAN (1962) Integration of chemical and biological control of *Chilo zonellus* (SWINHOE) the stalk borer of maize and jowar. *Proceedings of the Symposium on Advancing Frontiers of Life Sciences*, **19** : 119–125.

SAINI, M. L. &. P. D. SHARMA (1970) The relative efficacy of insecticides against lemon butterfly *Papilio demoleus* L. (Papilionidae : Lepidotera). *J. Res. P. A. U. Ludhiana*, **7** : 203–207.

SETHI, S. L. (1965) Insecticides for the control of citrus caterpillar, *Piapilio demoleus* LINN. *J. Res. P. A. U. Ludhiana*, **2** : 205–207.

SHARMA, R. P. & D. S. SHRIVASTAVA (1970) Studies on the chemical control of *Papilio demoleus* L. on *Citrus reticulata*. *Madras agric. J.*, **57**: 300-302.

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CONTROL OF *LASIODERMA SERRICORNE* FAB. INFESTATION OF DRY TURMERIC BY PHOSPHINE FUMIGATION

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(*Received 15 September 1977*)

Samples of turmeric collected from the local market were found to be infested with *Lasioderma serricorne* FAB. to the extent of 67.74 per cent on number basis. The weight loss recorded was 39.78 per cent. The fumigation of godowns with Celphos (Phosphine) at the rate of 140 tablet/100 m^3 resulted in complete kill of both larvae and adults. The absorption of phosphine by turmeric bulbs estimated was below detectable level one day after continuous exposure of 10 days.

(*Key words :* **Control of *Lasioderma serricorne*, turmeric, Phosphine fumigation**)

INTRODUCTION

The cigarette beetle, *Lasioderma serricorne* FAB. is a serious pest of stored tobacco and dry turmeric in India (FLETCHER, 1914; SONTAKAY, 1960). SRINATH & PRASAD (1975) reported 43.6 per cent market samples of turmeric infested with this insect. The laboratory control trials of this insect by fumigants and organic insecticides have been conducted in India (THIRUMAL RAO & NAGRAJ RAO, 1954; MENON *et al.*, 1961; JOSHI & KAUL 1965). Recently, we have conducted laboratory trials to test toxicity of some fumigants to the adults of tobacco beetle. No specific recommendation for field use to control infested turmeric is available. In view of the restrictions imposed for direct mixing of insecticides, only fumigants remain the choice presently. The present paper records the observation on the field application of phosphine and the extent of residues left in turmeric.

MATERIALS AND METHODS

During 1975-76, there was heavy infestation of this insect in stored turmeric in the market of Udaipur. Infested turmeric samples were collected and mixed thoroughly. The percentage infestation on number basis was determined taking 50 bulbs randomly in each replicate. Loss in weight of dry turmeric bulbs was also calculated (BAINS *et al.*, 1976). Fumigation of godowns, in which turmeric was stored in gunny bags, was done with celphos (Phosphine) @ 140 tablet/100 m^3. After an exposure period of 10 days the godowns were opened, the aeration was allowed for one day and the samples of fumigated turmeric were collected for residue estimation. The residue estimation of phosphine was done by a colorimetric method developed by BRUCE *et al.*, (1962) and recommended by the Joint Committee of FAO and WHO on pesticide residues (FAO/WHO, 1967).

RESULTS AND DISCUSSION

The data presented in Table 1 reveal that there was 67.74 per cent infestation of turmeric collected from the market on number basis as against the earlier record of about 43.6 per cent (SRINATH & PRASAD, 1975). Further the average number of holes recorded per bulb were 28.56. It gives to believe that such heavy average population of larvae and adults per bulb was 3.08 and 2.56 respectively, infestation (67.74%) would result in heavy loss on weight basis. The calculated loss of about 39.78 per cent in weight corroborates

TABLE 1. Percentage infestation and loss in weight of infested turmeric.

Samples	Percentage infestation on number basis	Loss in weight * (%)	Number of holes *	Number of alive insects present *		
				Larvae	adult	Total
I	76.67	39.92	27.20	3.60	2.60	6.20
II	60.00	36.31	26.00	2.80	2.40	5.20
III	82.00	47.62	32.00	4.00	3.40	7.40
IV	68.67	39.41	31.80	3.40	3.80	7.20
V	51.38	35.64	25.80	1.60	0.60	2.20
Average	67.74	39.78	28.56	3.08	2.56	5.64

* Average of 5 turmeric bulbs.

this assumption. The fumigation resulted in complete kill of larvae or adults in turmeric bulbs or in seems of gunny bags or in cracks and crevices of the godown, thus showing the efficacy of the phosphine. Our unpublished observations show that phosphine is effective against adults of *L. serricorne* in laboratory trials and recommended it for field use. The residue estimation studies revealed that the absorption of phosphine was below detectable level in turmeric bulbs one day after continuous exposure of 10 days. Thus, there appears to be no hazards from such field use of phosphine on turmeric.

Acknowledgements:– The authors are thankful to the Head, Department of Entomology, and Dean, College of Agriculture, Udaipur for providing necessary facilities and the traders of Udaipur for providing godowns for tests.

REFERENCES

BAINS, S. S., G. S. BATTU & A. S. ATWAL (1976) Distribution of *Trogoderma granarium* EVERTS and other stored grain insect pests in Punjab and losses caused by them. *Bull. Grain Tech.*, **14** : 18–29.

BRUCE, R. B., A. J. ROBBINS & T. O. TUFT (1962) Phosphine residues from 'Phostoxin' treated grain. *J. agric. Fd Chem.*, **10** : 18–21.

FAO/WHO (1967) *Evaluation of some pesticides residues in food.* Rome, FAO, PL : CP/15; Geneva WHO/Food Add. 67 : 32.237 p.

FLETCHER, T. B. (1924) *Some South Indian Insects*, Madras Govt. Publication, pp. 295–296.

JOSHI, H. C. & C. L. KAUL (1965) Studies on the protectectivity of jute bags impregnated with organic insecticides against red flour beetle and cigarette beetle. *Indian J. Ent.*, **27** : 491–492.

MENON, M. G. R., P. SARUP & H. D. VASU (1961) Effect of some modern insecticidal films on *Lasioderma serricorne* FABRICIUS (Anobiidae: Coleoptera). *Indian Oilseeds J.*, **5** : 60–62.

SONTAKAY, K. R. (1960) *Warehousing News Letter*, No. 3 : 43–44.

SRINATH, D. & C. PRASAD (1975) *Lasioderma serricorne* F. as a major pest of stored turmeric. *Bull. Grain Tech.*, **13** : 136–139.

THE INSECTICIDE ACT (1968) Govt. of India, General Manager, Govt. of India Press, New Delhi.

THIRUMAL RAO, S. D. & R. K. NAGRAJ RAO (1954) A note on the control of *Lasioderma serricorne* FAB., a pest of stored dry ginger. *Indian J. Ent.*, **16** : 416–418.

Entomon, 1978, *Vol.* 3, *No.* 1, *pp.* 59 *to* 61

EVALUATION OF SOME NEWER PESTICIDES FOR THE CONTROL OF SUGARCANE WEB MITE, *SCHIZOTETRANYCHUS ANDROPOGONI* HIRST.

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(Received 9 November 1977)

Chlorfenvinphos 0.05 per cent emulsion sprayed at the rate of 1000 litre per hectare gave good control of the sugarcane web mite, *Schizotetranychus andropogoni*. Methamidophos and monocrotophos (0.05 per cent) sprays suppressed the mite population for a short period only. Azinphos-methyl and phenthoate appeared to encourage multiplication.

(*Key words* : **Pesticide evaluation, control of sugarcane web mite, *Schizotetranychus andropogoni***)

INTRODUCTION

Sugarcane crop in India is attacked by five species of mites namely *Cligonychus indicus* HIRST, *Schizotetranychus andropogoni* HIRST, *Aceria sacchari* CHANNABASAVANNA, *Tydeus* sp., and *Tarsonemus* sp. Of these *S. andropogoni* has been noticed over a larger area in the northern sugarcane growing tracts. From 1973 to 1975 heavy infestations of *S. andropogoni* have been observed at the Institute farm. Ratoons are severely infested, the mite population ranging from 2500 to 3000 live webs per leaf, covering almost the entire leaf lamina. The infested leaves tended to dry up fast.

Chemicals recommended earlier for the control of the mite include parathion 0.02 to 0.05 per cent (AGARWAL, 1957; PRASAD & PRASAD, 1957), dicofol 0.1 per cent (LAL *et al.*, 1962), Chlorbenside .02 kg + malathion .1 kg (miscible liquid) per hectare (KALRA & CHAUDHURY, 1965), carbophenothion dicofol and plictron 0.05 per cent and monocrotophos 0.075 per cent (GUPTA *et al.*, 1972) all as foliar sprays. Attempts to control the mite with 0.1 per cent dicofol at Institute farm in 1974 have not been successful. Results of laboratory and field evaluations undertaken using some newer chemicals are presented in this paper.

MATERIALS AND METHODS

Leaf dip technique (DITTRICH, (1962) was employed to test the efficacy of the chemicals against eggs, nymphs and adults of mite *Schizotetranychus andropogoni*. The mite was reared in the laboratory on sugarcane leaf pieces (15 cm) for laboratory tests. Leaf pieces supporting five webs of apparently equal size each were dipped in the toxicant solutions for 30 seconds. Four leaf pieces were used for each toxicant (see Tables for the names of toxicants used). Leaf pieces with the mites dipped in water served as check. Mortalities were recorded after 24 hours of the treatments.

To asses the residual effectiveness of the pesticides 120 cm tall plants of sugarcane (Co 1148 raised in pots were sprayed with the test chemicals to run off level. Plants sprayed with water were kept as check. The treatments were replicated four times. Ten adult mites were released on the ventral surface of leaf pieces clipped off at random, from the sprayed plants at intervals of 1, 4, 7, 10 and 15 days after the treatments. Mortality of mites was recorded 24 hours after the release. 'PT' values (PRADHAN, 1967) were used to compare persistence of the pesticides.

A field trial was conducted on a spring planted crop of sugarcane (Co 1148) in the Institute farm. Two 12 m rows separated by a buffer row on either side, forming one unit of treatment, were sprayed at

the rate of 1000 litre of spray fluid per hectare with a knapsack sprayer. The experiment was laid out in randomized block design with 4 replications.

Per cent reduction in live webs was recorded for each treatment before and 2, 5, 10 and 15 days after treatment as observed on the fifth leaves of five randomly chosen plants. Data were analysed for variance. All chemicals were sprayed at 0.05% ai. The desired concentration was prepared from the commercial formulations. Abbott's formula (ABBOTT, 1925) was used for correcting the percentage mortality in the treatments.

RESULTS AND DISCUSSION

Data in Table 1 show that all pesticides except ekadrin killed eggs. Chlorfenvinphos, monocrotophos and dicofol were effective against the nymphal and adult stages of the mite. Rattan LAL *et al.*, (1962) have reported earlier ovicidal action of carbophenothion, thiometon, phorate, mevinphos, malathion, dimethoate and diazinon beside kelthane.

As indicated in Table 2 the pesticides as per PT index values could be grouped as chlorfenvinphos, monocrotophos, dicofol azinphosmethyl, ekadrin, methamidophos phenthoate.

TABLE 1. Per cent mortality of different stages of *S. andropogoni* dipped in emulsion of different toxicants.

Toxicant (0.05% ai)	egg	nympth	adult
Chlorfenvinphos	100	100	100
Monocrotophos	100	100	100
Methamidophos	100	81.5	96.3
* Eakadrin	70.4	94.3	80.6
Dicofol	100	100	100
Phenthoate	100	84.1	88.0
Azinphosmethyl	100	83.7	88.3

* Endrin+Thiometon

Application of chlorfenvinphos at 0.05 per cent concentration spray proved to be the most effective in arresting the mite multiplication and new web formation for fifteen days (Table 3). Methamidophos and monocrotophos were effective only for five days. Ineffectiveness of dicofol in the present investigation was contrary to the results reported by GUPTA *et al.* (1970). There was appreciable increase in live web

TABLE 2. Per cent mortality of adults of *S. andropogoni* exposed to pesticide treated sugarcane leaves at different intervals after treatment.

Pesticide (0.05% ai)	Percentage mortality of adults at different intervals in days					
	1	4	7	10	15	PT index
Chlorfenvinphos	100	95.6	100	100	60.6	1368.6
Monocrotophos	100	100	100	78.3	Nil	1134.0
Methamidophos	100	Nil	6.4	13.6	Nil	360.0
Ekadrin (Endrin+Thimeton)	100	22.7	13.0	12.5	7.1	474.0
Dicofol	60.0	39.0	50.4	70.0	59.0	834.0
Phenthoate	100	27.7	11.2	3.2	5.0	442.2
Azinphosmethyl	86.6	68.4	13.1	4.3	Nil	516.0

TABLE 2. Relative effect of different chemicals on the control of *S. andropogoni* on sugarcane.

Chemical (0.05% ai)	Pre-spraying population of live webs per 20 leaves.	Per cent decrease in live web population at different intervals (days) 2	5	10	15
Chlorfenvinphos	341	100	99.6	91.8	85.8
Monocrotophos	305	91.4	73.8	33.8	38.5
Mathamidophos	340	97.6	87.2	46.3	18.8
Ekadrin (Endrin+thiometon)	315	10.5	1.3	16.9	34.5
Dicofol	366	13.3	41.9	35.4	52.1
Phenthoate	392	+ 19.5	+28.3	36.6	49.8
Azinphosmethyl	366	+112.1	+34.1	21.1	48.2
C D (P=05)	N S	16.46	7.55	23.11	N S
Check (No treatment)	330	+ 91.1	+ 249.1	+ 1.7	−14.1

Weather conditions during the trial:

minimum temperature	20.5°–27.2°C
Maximum temperature	28.0°–36.0°C
Relative humidity	72.0–94.0%
Total rainfall	296.5 mm
Total rainy days	8

population in plots treated with azinphosmethyl and phenthoate. Similar increase in population of red spider mite, *Tetranychus cinnvarinus* BOISD on brinjal plants was observed by UTHAMASSAMY *et al.* (1976). They attributed it to changes in the biochemical constituents in the treated plants. However, precise information on this aspect is lacking.

Acknowledgements:— Authors are greatful to Dr. KISHAN SINGH, Director and Shri P. N. AVASTHY, Entomologist, Indian Institute of Sugarcane Research, Lucknow for kindly providing necessary facilities and critically going through the manuscript.

REFERENCES

ABBOTT, W. S. (1925) A method of computing the effectiveness of insecticides. *J. econ. Ent.*, **18** : 265–267.

AGARWAL, R. A. (1957) The sugarcane mite *Schizotetetranychus andropogoni* HIRST. and its control. *Indian Sug.*, **7** : 394–399.

DITTRICH, V. (1962) A comparative study of toxicological test methods on a population of the two spotted spider mite (*Tetranychus telarius*). *J. econ, Ent.*, **55** : 644–648.

GUPTA, S. K., A. S. SIDHU & M. S. DHOORIA (1972) Occurrence of *Schizotetranychus andropogoni* HIRST. on sugarcane in the Punjab and its control. *Indian Sug.*, **22** : 335–337.

KALRA, A. N. & J. P. CHOUDHARY (1965) Studies on sugarcane mite, *Schizotetranychus andropogoni* HIRST. *Proc. XII Int. Soc. Sug. Cane Technol. Puerto Rico*, 1454–1459.

LAL, RATTAN, B. K. RAI & SHASHI KANTA (1962) Evaluation of ovicidal and residual efficacy of some pesticides against the sugarcane mite, *Schizotetranychus andropogoni* HIRST. (*Tetranychidae: Acarina*). *Indian J. agri. Sci.*, **32** : 305–308.

PRASAD, S. N. & A. R. PRASAD (1957) An experiment on the chemical control of *Schizotetranychus* sp. (Tetranychidae : Acarina) infesting *Saccharum spontaneum* in Bihar. *Indian. J. Ent.*, **19**: 300–301.

PRADHAN, S. (1967) Strategy of integrated pest control. *Indian J. Ent.*, **29** : 105–122.

UTHAMASAMY, S., D. KUMARESON, P. P. VESUDAVA MENON & S. JAYARAJ (1976) Biological changes in egg plant (*Solanum melongena*) due to insecticidal spary in relation to mite incidence. *Indian J. exp. Biol.*, **14** : 639–690.

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MORPHOLOGY OF THE EXTERNAL AND INTERNAL GENITAL ORGANS OF MALE *SPHYRACEPHALA HEARSEIANA* WESTW. (DIOPSIDAE : DIPTERA)[1]

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(*Received 3 December 1977*)

In *Sphyracephala hearseiana* sexes are separate with distinct sexual dimorphism. The male genitalia are highly complex structures formed mainly by the ninth abdominal segment. The ninth tergite forms an arched periandrium whereas its sternum is reduced to a triangular plate. The aedeagal apodeme is fused wih the ninth sternum or hypandrium, forming a complex structure which is being reported for the first time. A pair of surstyli and a pair of cerci are seen as periphallic organs to help during copulation. Pregonites are quadrate sclerites while the postgonites are elongated and valvular. The phallus is elongated with three distinct, basiphallic, mediphallic and distiphallic regions. The internal organs of reproduction comprise paired tubular testes, a pair of vas deferens, bulbus communis, a glandular pre-ejaculatory duct and an ejaculatory apparatus. There are two prominent elongated accessory glands opening independently into the bulbous communis.

(*Key words : male* genital organs, *Sphyracephala hearseiana*)

INTRODUCTION

The *Sphyracephala hearseiana* WESTW., popularly known as "stalked eyed flies" are a group of morphologically interesting flies. The paper deals with the functional morphology of the reproductive organs of the male *Sphyracephala hearseiana* WESTW.

MATERIAL AND METHODS

For the study of the external genitalia, adult flies were boiled in dilute KOH solution (5%) for about thirty minutes and then kept overnight in the same solution for the removal of muscles and partial bleaching. The alkaline effect of the KOH was neutralised by keeping these flies in glacial acetic acid for about thirty minutes. Stained and unstained mounts were made in Canada balsam. Alcoholic Bouin fixed flies were dissected in Canada balsam under the high power bionocular microscope. The gross anatomy of the genital organs was studied in dissections of the fresh and alcoholic Bouin-fixed flies. To obtain serial longitudinal and transverse sections, the flies were double embedded in celloidin.

RESULTS AND DISCUSSION

External Genitalia: The male genitalia of *S. hearseiana* are highly complex structures formed mainly by the modification of the ninth abdominal segment which is kept folded on the ventral side of the seventh segment. The ninth abdominal segment has undergone a high degree of modification and it has become difficult to determine the identity of its sternum or pleura.

The eighth segment has more or less lost its identity and is represented only by a small arched narrow strip of the tergite, slightly broader at the lateral ends attached to the anterior extremity of the ninth tergite or the "periandrium." Its sternal component too is very much reduced and modified and is seen as a more or less triangular plate medio-laterally. It is fused with the aedeagal apodeme or phallic apodeme forming a complex structure. GRIFFITHS (1972) also reports the fusion of the phallic apodeme with the body segment but does not specify the identity of the segment involved.

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[1] Contribution No. 240 from School of Entomology, St. John's College, Agra-282002, India.

The ninth tergite (Fig. 2) is highly modified and forms the arched periandrium (epandrium). Attached to the latero-ventral extremity of the periandrium on either side are the surstyle 'style' of FLUKE (1951) and STUCKIENBERG (1960) "surstyli or edita" of CRAMPTON (1942), "clasper", "paralobe", or "inferior forcepes" of BASDAN & COLLIN (1958) or "harpagones" of NAYAR (1965). These are periphallic organs that help during copulation. On the posterior extremity of the periandrium are two comparatively large elongated conical cerci. The inner sides of the cerci and the surstyli are supplied with numerous prominent spines. The periandrium (eighth segment onwards) along with associated structures are folded on to the ventral side of the seventh segment.

The phallic organs of *S. hearseiana* are simpler than many of the Cyclorrhapha. The phallic apodeme (aedeagal apodeme) measures about 0.22 mm long and is fused with the reduced modified eighth sternite and forms a complex structure. The ninth sternite or the hypandrium (Fig. 1) too is modified. A hypandrial apodeme found in many other Diptera is missing and the whole sternite is very much reduced medially, whereas laterally the arms are broader and are fused slightly in the median region with the eighth sternum. Thus the eighth and ninth sterna and the aedeagal apodeme together form a complex and separates out as a single unit while dissecting. The lateral distal arms of the hypandrium are broadened and articulates with the pregonites. The anterior articulating region of the aedeagal apodeme is well sclerotised. The basiphallus is slightly swollen and is supplied by two elongated sclerites, the penial valves (Fig. 1). Anteriorly the basiphallus is articulated with mediphallus and the fusion is not easily distinguishable. The phallus is more or less rectangular with a median groove. The grooved region has got numerous serrations. On the base of the phallus on either side are the remnants of the paraphallus in the form the reduced sclerites.

On either side of the basiphallus (Fig. 1) articulating with the distal arms of the hypandrium are seen two quadrate sclerites, the pregonites and distal to them, the slightly elongated postgonites. These are again periphallic structures presumably sensory in function.

The narrow ejaculatory duct (Fig. 3) originating at the ejaculatory apparatus opens at the base of the basiphallus.

Internal organs of reproduction

The male internal reproductive system comprises a pair of long tubular testes, a pair of vas deferens, a pair of accessory glands, a glandular pre-ejaculatory duct, a highly specialized ejaculatory apparatus and a long narrow ejaculatory duct opening at the base of the aedeagus.

The testes (Figs. 3 & 7) : The testes are long cylindrical, tubular enlarged sac like dark brownish bodies lying ventrolaterally at the intersegmental region between the fourth and fifth abdominal segments, more or less obliquely to the long axis of the body. In between them are seen the alimentary canal, rectal sac and other visceral organs. Each testis (Fig. 3) measures about 0.52 mm in length and 0.26 mm in width. The pointed portion alone measures about 0.46 mm in length. The testes are enveloped in a tracheal mesh and are well provided with nerves.

Four successive regions of development can be distinguished in a testes. The wall of the testis comprises a single layer of syncytial epithelium, with very prominent widely scattered nuclei. In *Syrphus balteatus*,

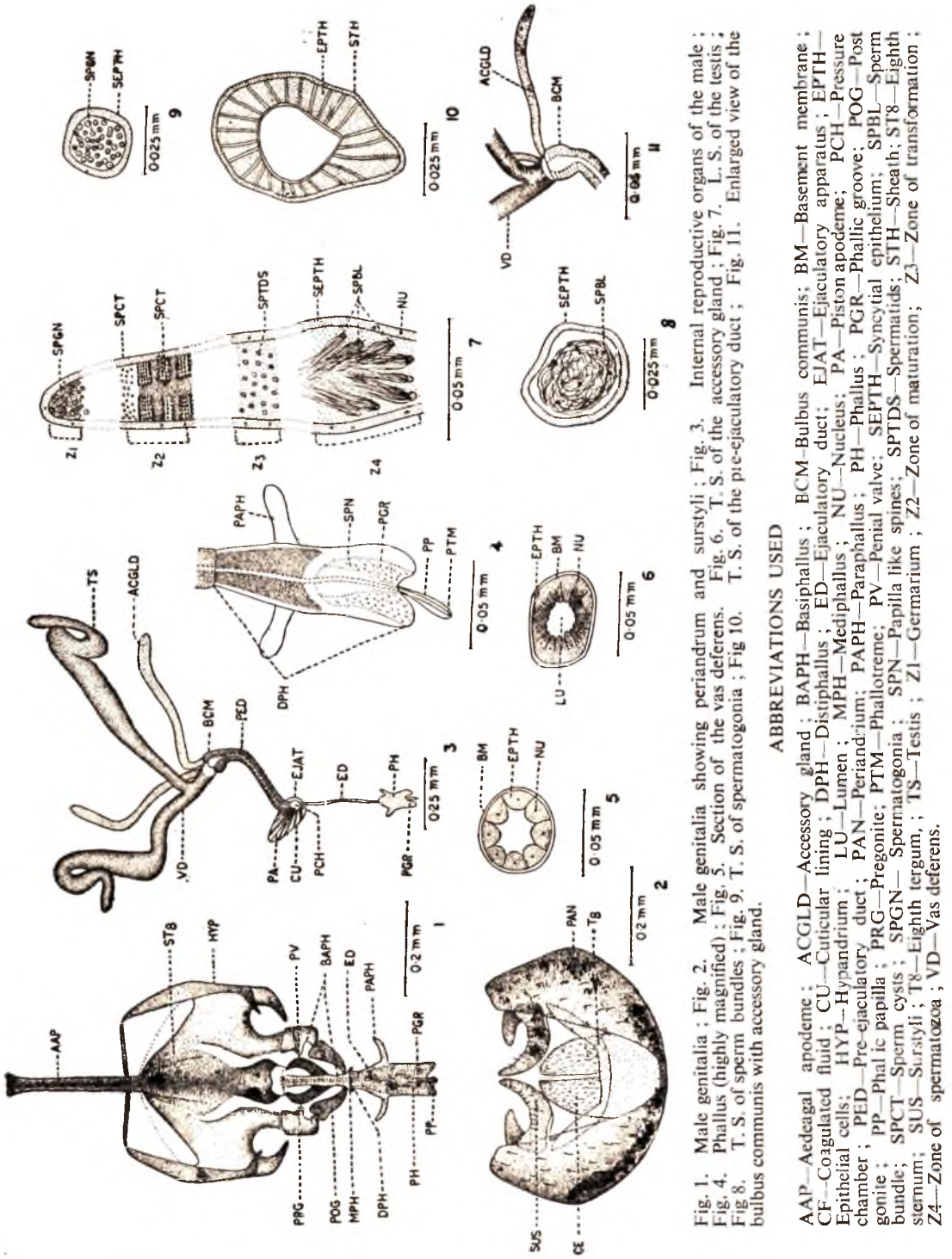

Fig. 1. Male genitalia ; Fig. 2. Male genitalia showing periandrum and surstyli ; Fig. 3. Internal reproductive organs of the male ; Fig. 4. Phallus (highly magnified) ; Fig. 5. Section of the vas deferens. Fig. 6. T. S. of the accessory gland ; Fig. 7. L. S. of the testis ; Fig 8. T. S. of sperm bundles ; Fig. 9. T. S. of spermatogonia ; Fig 10. T. S. of the pre-ejaculatory duct ; Fig. 11. Enlarged view of the bulbus communis with accessory gland.

ABBREVIATIONS USED

AAP—Aedeagal apodeme ; ACGLD—Accessory gland ; BAPH—Basiphallus ; BCM—Bulbus communis; BM—Basement membrane ; CF—Coagulated fluid ; CU—Cuticular lining ; DPH—Distiphallus ; ED—Ejaculatory duct; EJAT—Ejaculatory apparatus ; EPTH—Epithelial cells; HYP—Hypandrium ; LU—Lumen ; MPH—Mediphallus ; NU—Nucleus; PA—Piston apodeme; PCH—Pressure chamber ; PED—Pre-ejaculatory duct ; PAN—Periandrium; PAPH—Paraphallus ; PH—Phallus ; PGR—Phallic groove; POG—Post gonite ; PP—Phallic papilla ; PRG—Pregonite; PTM—Phallotreme; PV—Penial valve; SEPTH—Syncytial epithelium; SPBL—Sperm bundle; SPCT—Sperm cysts ; SPGN— Spermatogonia ; SPN—Papilla like spines; SPTDS—Spermatids; STH—Sheath; ST8—Eighth sternum; SUS—Surstyli ; T8—Eighth tergum, ; TS—Testis ; Z1—Germarium ; Z2—Zone of maturation; Z3—Zone of transformation ; Z4—Zone of spermatozoa ; VD—Vas deferens.

NAYAR (1965) reports a two layered wall, a thick tunica externa and a thin tunica interna. STERN (1941) thinks the tunica externa to be a sheath of pigment cells in *Drosophila* while considers it as a connective tissue, filled with stored nutritive material in mosquito.

Four distinct zones of development can be seen in longitudinal sections viz., Z_1 – zone of spermatogonia (germarium), Z_2 – zone of maturation, Z_3 – zone of transformation, and Z_4 – zone of spermatozoa. Z_1 has got compactly packed large sized spermatogonia cells whereas Z_2 contains small round cells more or less irregularly arranged with prominent eosinophilic nuclei, Z_3 with cells transformed into sperm cysts arranged in layers and Z_4 with sperms with their heads directed towards wall and the tails towards the centres. The heads of the spermatozoa from one sperm cyst remain closely associated with each other forming the separate bundles of the sperms.

Vas deferens : The vas deferens or testicular duct (Fig. 3) originates from the inner margin of the testis. The duct from each of the testis runs obliquely in the anterior margin of the fifth abdominal segment and they come closer to each other and fuse to form a short common vas deferens. The common vas deferens opens into the expanded bulbus communis also open independently into the bulbus communis. The vas deferens measures about 0.2 mm in length and 0.08 mm in diameter and is of almost uniform thickness throughout its course. It does not show any distension to form a seminal vesicle. It has been reported in *Melanagromyza obtusa* (IPE, 1967) and *Syrphus balteatus* (NAYAR, 1965) that the vasa deferentia come together and is enclosed in a common sheath without really fusing to form a common duct. This is a common feature in Diptera but not found in this insect. The sperm bundles are seen packed all along the length of the vasa deferentia.

Bulbus communis (Figs. 3 & 11) : The point where the accessory glands and the vasa deferentia meet, is swollen and is differentiated as a bulb-like structure, the bulbus communis as reported by IPE (1967) in *Melanagromyza obtusa*. The lumen of the bulbus communis is wider and appears to have a distinct chitinous lining. From the bulbus communis originates a glandular duct of uniform diameter measuring about 0.62 mm in length and 0.06 mm in width, the pre-ejaculatory duct. This duct though lined internally by chitin has got an outer glandular cellular epithelial covering suggesting a glandular function. Pre-ejaculatory duct leads into an ejaculatory apparatus which functions as pumping organ for sperms.

Ejaculatory apparatus (Fig. 3) : The ejaculatory apparatus is more or less ovoid and slightly tapering towards one side. The pre-ejaculatory duct enters in on the broader side which forms a pressure chamber (IPE, 1967). From the opposite side of the pressure chamber originates a minute duct, the ejaculatory duct which opens at the base of the phallus. The ejaculatory apparatus is a pumping organ with a chitinous piston apodeme projecting on to one side from the pressure chamber. There are radiating sets of strong muscles extending from the periphery to the inner base of the apodeme and pressure chamber. The contraction of these muscles creates a pressure inside the pressure chamber strong enough to pump its contents into the aedeagus through the narrow elongated ejaculatory duct.

The pressure chamber gland recorded by IPE (1967) in *Melanagromyza* could not be traced in this fly. The discovery of the ejaculatory apparatus in this fly, so far reported only from the Agromyzidae and Drosophilidae, is interesting.

Ejaculatory duct (Fig. 3) : It is a very narrow chitinous duct with uniform diameter. There is no trace of any epithelial

layer internally or externally. It measures about 0.16 mm in length and 0.08 mm in width and opens at the base of the aedeagus.

The aedeagus or phallus : The aedeagus or phallus (Figs. 1 & 4) is elongated with three distinct regions, the basal basiphallus (Fig. 1), the middle mediphallus and the distal distiphallus. The basiphallus is articulated with the aedeagal and the complex formed by its fusion with hypandrium. The basiphallus also has got two lateral sclerotisations, the penial valves, and is broader basally. The ejaculatory duct enters the phallus through the basiphallus. Distally the basiphallus articulates with a short sclerotised mediphallus. The mediphallus has got a wider distal end which is articulated with the distiphallus. The distiphallus is more or less quadrate with a slightly wider grooved distal end. The paraphallic elements (Figs. 1, 3, 4) are seen on either side of the aedeagus as two small projections. The distal end is grooved and the groove exhibits numerous minute conical papilla-like spines. The opening of the ejaculatory duct is seen at the tip of a small papilla-like projection, the phallic papilla seen inside the groove. The base of the phallic papilla has a spherical bulb-like expansion. The distal free end of the papilla also is slightly swollen than its midregion.

The accessory glands (Figs. 3&6): There are two prominent, elongated tube-like accessory glands occupying the posterior half of the fifth abdominal segment. The accessory gland opens independently into the bulbous communis. Each gland measures about 0.8 mm in length and 0.06 mm in width and is bounded by a single layer of epithelial cells with distinct nuclei. The inner borders of the epithelial cells are lined by a thin cuticular lining. Externally the epithelial cells are bounded by a distinct basement membrane. The cytoplasm of the cell is granular. The lumen of the gland is filled up with a secretory product which stains red with Mallory's triple stain. In *Syrphus balteatus* (NAYAR, 1965) the gland opens through a short duct and in *M. obtusa* it opens into the bulbus communis (IPE, 1967) as in the case of *S. hearseiana.*

Acknowledgements :— I wish to express my deep gratitude to Dr. IPE M. IPE, School of Entomology St. John's College, Agra for guidance and help during these stuides. I am also grateful to Dr. SANTOKH SINGH, Head of Zoology and Dr. P. I. ITTYERAH, Principal of St. John's College, Agra for providing facilities. My thanks are also due to Dr. (Mrs.) A. IPE and Miss ANITA DANIELS of School of Entomology, for their help in various ways.

REFERENCES

BASDAN, E. B. & J. E. COLLIN (1958) On the examination of some Meigen and Zetterstedt specimens of Campiacheta MACQUART (Diptera : Diastatidae). *Proc. R. ent. Soc. Lon.*, **27B** : 133–144.

CRAMPTON, G. C. (1942) The Diptera or True flies of Connecticut. *Conn. Geol. Nat. Hist. Survey Bulletin*, No. **64** : 10–165.

FLUKE, C. L. (1951) The male genitalia of *Syrphus*, *Epistrophe* and related genera (Diptera : Syrphidae). *Wisconsin Acad. Sci. Arts and Letters*, **115** : 45.

GRIFFITHS, G. C. D. (1972) The phylogenetic classification of Diptera Cyclorrhapha. 341.

IPE, I. M. (1967) A detailed morphological study of the external and interal genital organs of male *Melanagromyza obtusa* (MALLOCH) a pest of *Cajanus indicus* L. *Indian J. Ent.*, **29** : 1–10.

NAYAR, J. L. (1965) Reproductive system and external genitalia of *Syrphus balteatus* DE GEER (Diptera : Syrphidae). *Indian J. Ent.*, **27** : 31–45.

STERN, C. (1941) Interspecific relations vas-deferens and testes *Drosophila*. *Jour. exp. Zool.*, **24** : 113–158.

STUCKENBERG, B. R. (1960). Diptera (Brachycera) : Rhagionidae, 216–308, in *South African Animal Life*, Vol. 8 (ed., Hanstrom Bruch & Rudebeek).

Entomon, 1978, *Vol*, 3, *No*. 1, *pp* 69 *to* 75

COMPARATIVE MORPHOLOGICAL STUDIES ON THE MALE REPRODUCTIVE SYSTEM OF *BRUCHIDIUS* (BRUCHIDAE : COLEOPTERA)

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(*Received 4 July 1977*)

A comparative morphological study of the male reproductive system has been attempted on 19 species of the genus *Bruchidius* (Bruchidae). The testes are two pairs; either dirty white or yellow and may be pear-shaped, globular or flask-shaped. They are separated into 1 to 18 follicles by means of incomplete internal septa. The vas efferens starts from within the testis, and the two of a side independently open into a common vas deferens, which in turn opens into the horn of the ejaculatory duct. The ejaculatory duct may be a short tube or forms an incomplete or a complete loop before entering the phallobase. The accessory glands are ectadenia and mesadenia and are in four pairs, showing variations in shape, structure and disposition. The lateral gland is either two- or four-lobed. The number of testicular follicles as well as the shape, structure and disposition of glands are the higher taxonomic characters, and a thorough characterization, including the external characters, demands a split of the genus.

(*Key words*:– **Comparative morphology, male reproductive system, *Bruchidius*)**

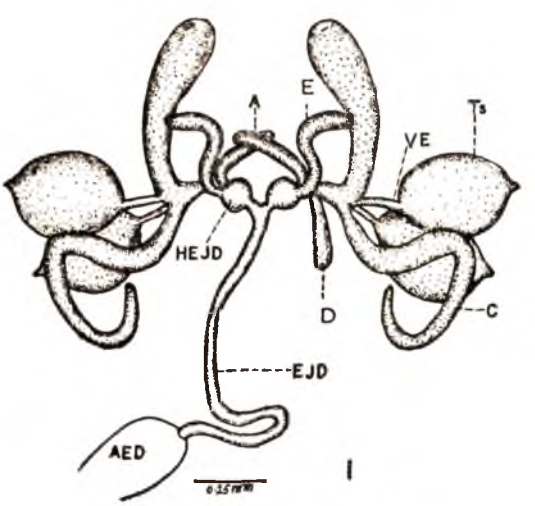
INTRODUCTION

The genus *Bruchidius* is widely represented in India and the adults attack mostly the ornamental and wild leguminous plants. The eggs are laid on green pods, the larvae bore through into the seeds and the adults emerge after making holes in pods.

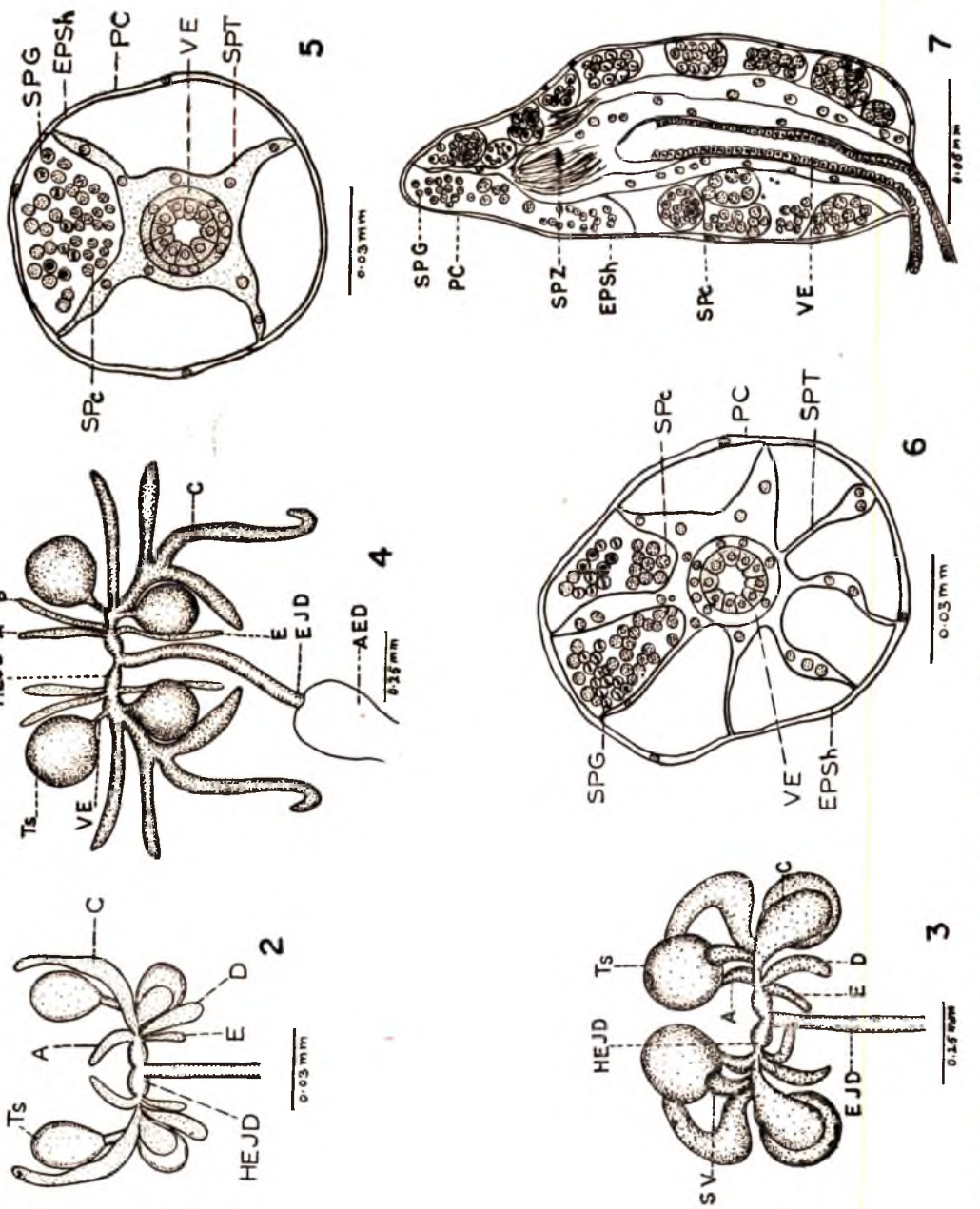
The sifting of the literature reveals that the study on the reproductive systems of Bruchidae is very scant, and almost no account is available on the genus *Bruchidius*, except that of PARNELL (1964), on the male reproductive system of *Bruchidius ater*. However, DAVIAULT (1928), ZACHER (1930), MUKERJI & BHUYA (1937), SRIVASTAVA (1953) and PAJNI (1968) have made some investigations on the male reproductive system of certain bruchids. The present work is a comparative study on the morphology of reproductive system of 19 species of the genus *Bruchidius*, and to assess the value of higher taxonomic characters. The material for the present studies was collected from North-West India.

OBSERVATIONS AND DISCUSSION

The components of male reproductive system are two pairs of testes, the vasa efferentia, the vasa deferentia, the ejaculatory duct and the accessory glands.



1. Male reproductive system of *Bruchidius cassiae*.



2. Male reproductive system of *Bruchidius angustifrons* ; 3. Male reproductive system of *B. tephrosiae* ; 4. Male reproductive system of *B. lineolatus* ; 5. T. S. of testis of *B. cassiae* showing quardifollicular condition; 6. T. S of testis of *B. dimorphous*, showing octofollicuar conditions ; 7. L. S. of testis of *B. albizziae*, showing the start of vas efferens.

Testes

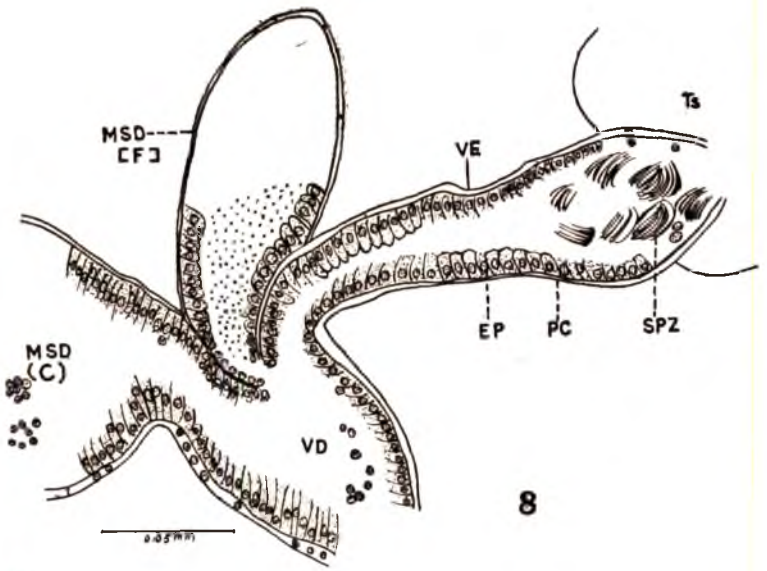
The testes are situated ventral to the gut in all the members. There are two testes on either side as also stated by ZACHER (1930), MUKERJI & BHUYA (1937), PARNELL (1964) and PAINI (1968) and not four as mentioned by DAVIAULT (1928). They occupy the fourth and fifth abdominal segments, when mature. The colour is dirty white except in *Bruchidius albizziae, B. saundersi* and *B. aureus,* where they are yellow. They vary in shape, size and number of follicles.

They are pear-shaped in *Bruchidius cassiae* (Fig. 1), flask-shaped in *B. minutus, B. vulgaris, B. angustifrons* (Fig. 2), *B. sahlbergi, B. saundersi, B. mimosiae, B. albizziae, B. flavovirens* and *B. schilskyi;* globular in *B. tephrosiae* (Figs. 3, 4), *B. andrewesi, B. dimorphous, B. maculipygus, B. lineolatus, B. multilineolatus* and *B. pygomaculatus.* The follicles of testes vary from 1 to 18 and a unifollicular condition is met with in *B. minutus, B. vulgaris, B. angustifrons* and *B. tephrosiae;* quadrifollicular in *B. cassiae* (Fig. 5), *B. andrewesi;* hexafollicular in *B. shalbergi, B. aureus* and *B. schilskyi;* octofollicular in *B. dimorphous* (Fig. 6), *B. mimosiae, B. albizziae, B. lineolatus* and *B. urbanus.* Apart from above grouping, there are nine follicles in *Bruchidius maculipygus,* and *B. pygomaculatus,* twelve in *B. saundresi* and *B. flavovirens,* and eighteen in *B. multilineolatus.* MUKERJI & BHUYA (1937) have also mentioned eight follicles in *Bruchus quadrimaculatus;* SRIVASTAVA (1953) has shown twelve in *Laria affinis* and PAJNI (1968) eight in *Callosobruchus maculatus.* The study reveals that these follicles cannot be made out externally; rather incomplete testicular septa (Figs. 5, 6) separate them internally. The septa appear radiating like the spokes of a wheel as described by KRAUSE (1946) in *Passalus carnutus.* The follicles are bound together by an external investing membrane as also mentioned by MUKERJI & BHUYA (1937), SRIVASTAVA (1953) and PAJNI (1968).

Each testis is covered over by an outer syncytial peritoneal covering and an inner epithelial sheath which extends into the cavities of testes in all the species to form incomplete septa. Internal to the epithelium are present the sperm cells in various stages of development as described by SNODGRASS (1935) and IMMS (1957). The spermatozoa develop in cysts after which the cyst membranes rupture, releasing the mature spermatozoa. The mature spermatozoa do not form bundles and are with distinct nuclear heads.

Ducts

The vas efferens starts from within the testis (Fig. 7), and each one varies from 0.08 mm to 0.26 mm in the different species. It is short and tubular except in *Bruchidius tephrosiae,* in which it dilates at the base of testis to form a seminal vesicle (Fig. 3). The vasa efferentia of each side open independently into the vas deferens (Figs. 1–4&8), the latter being labelled as vas deferens by ZACHER (1930), common vas deferens by PAJNI (1968) and the common duct by MUKERJI & BHUYA (1937). MUKERJI & BHUYA (1937), SRIVASTAVA (1953) and PAJNI (1968) have also mentioned that each vas efferens opens independently in the vas deferens, whereas ZACHER (1930) has mentioned that the two of ecah side unite before opening into the vas deferens in *Zabrotes subfasciatus.* The wall of the vas efferens is composed of a single layer of well marked epithelial cells, resting on a basement membrane and covered on the exterior by a layer of connective tissue (Fig. 8). The epithelial cells are small and may be cuboidal or columnar in the different members. However, they are devoid of any protoplasmic processes as described by ZACHARUK (1958).



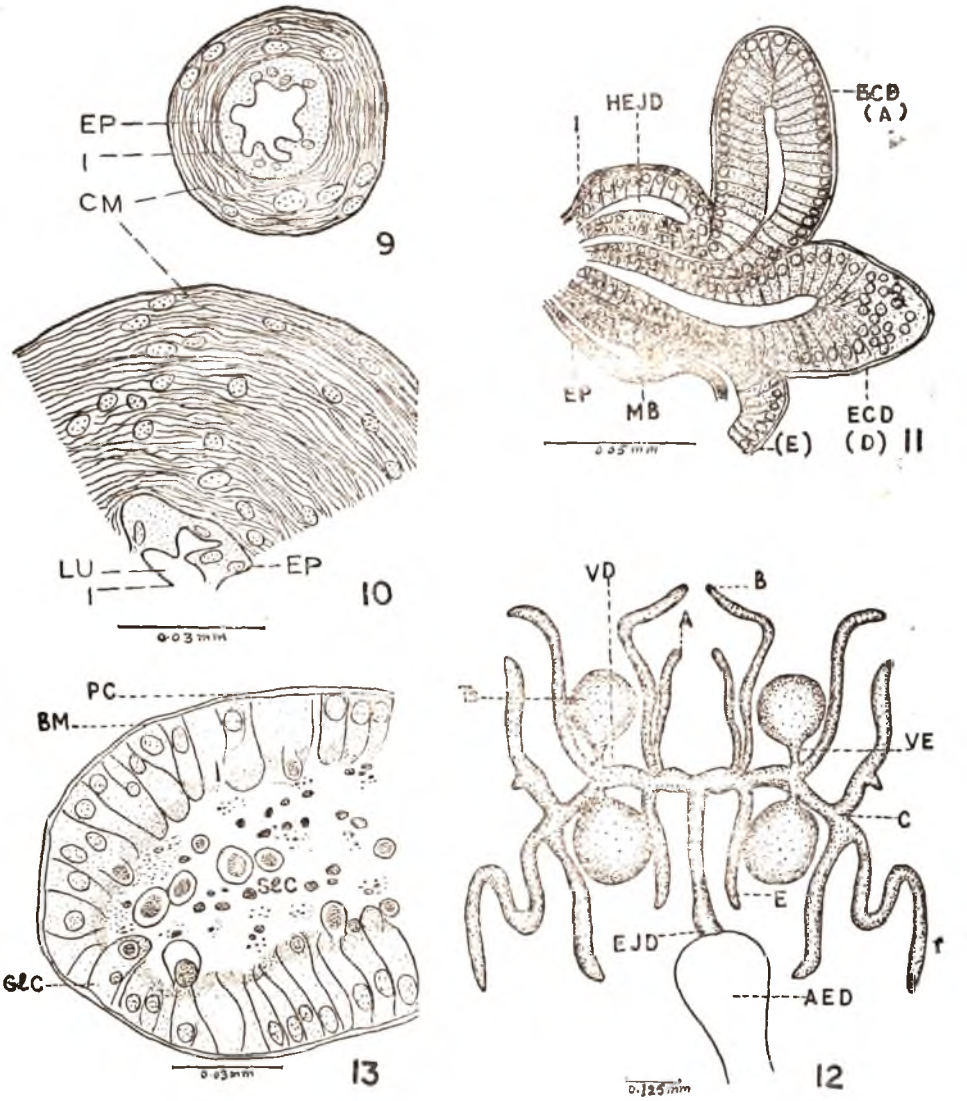
8. Vertical section of male reproductive system of *B. albizziae*, showing the structure of vas efferens, vas deferns and lateral gland.

The vas deferens is a short tube and varies from 0.1 mm to 0.52 mm in length in the different members and opens into the horn of ejaculatory duct (anterior swollen part of ejaculatory duct). The wall is similar to that of vas efferens (Fig. 8).

The ejaculatory duct is a median tube lying ventral to the digestive tract and divides anteriorly into two lateral, pear-shaped and dilated horns in all the members (Figs. 1–4). ZACHER (1930), MUKERJI & BHUYA (1937) and, SRIVASTAVA (1953) have all called them as prostate glands, whereas, PAJNI (1968) named them as lateral ejaculatory ducts on the basis of embryology. The two horns coalesce mesially and form the median ejaculatory duct, which is uniform in diameter except in *B. saundersi*, where its diameter increases slightly at its posterior end. It varies in length from 0.62 mm to 1.40 mm in the different members. It is short and straight in most of the species but forms a complete loop in *B. minutus, B. vulgaris, B. cassiae, B. angustifrons, B. tephrosiae and B. andrewesi* and an incomplete loop in *B. mimosiae* and *B. schilskyi*. The phallus, when everted during copulation carries the ejaculatory duct with it and the gonopore opens to the exterior at the tip of endophallus. The epithelial layer of ejaculatory duct forms a syncytium except in *B. sahlbergi* and *B. aureus*. The circular muscle fibres are considerably thick and so is the intima (Figs. 9, 10). The intima is thrown into irregular folds in the anterior region of the duct in species like *B. angustifrons* (Fig. 9), *B. tephrosiae, B. andrewesi, B. saundersi* and *B. aureus*. The lumen is wide in the anterior region and considerably decreases in the posterior region (Figs. 9, 10), the muscles are thick in the latter.

Accessory glands

The accessory glands associated with the male reproductive system in Coleoptera are either ectodermal or mesodermal in origin and are called as ectadenia and mesadenia respectively (ESCHERICH, 1894;



9. T. S. of ejaculatory duct of *B. angustifrons*, showing the anterior part : 10. T. S. of ejaculatory duct of *B. angustiforns* showing the posterior part ; 11. L. S. showing the structure of horn of ejaculatory duct and the structure of glands A, D, and E ; 12. Male reproductive system of *B. multilineolatus* ; 13. A part of the mesadenia gland C.

ABBREVIATIONS USED

A—Anterior internal gland ; AED—Aedeagus ; B—Anterior external gland ; BM—Basement membrane; C—Lateral gland ; CM—Circular muscles ; D—Posterior external gland ; E—Posterior internal gland ; ECD—Ectadenia gland ; EJD—Ejaculatory duct ; EP—Epithelium ; EPSH—Epithelial sheath ; GLC—Glandular cell ; HEJD—Horn of ejaculatory duct ; I—Intima ; LU—Lumen ; MB—Muscle fibres ; MSD—Mesdenia gland ; PC—Peritoneal covering ; SeC—Secretion ; SPC—Spermatocyte ; SPG—Spermatogonia ; SPT—Septum ; SPZ—Spermatozoa ; SV—Seminal vesicle ; Ts—Testis ; VD—Vas deferns ; VE—Vas efferens.

BLATTER, 1897). However, BORDAS (1900) labelled them as external and internal glands in his studies. In genus *Bruchidius*, there are present 4 pairs of glands of which one pair is of mesadenia and three pairs of ectadenia . MUKERJI & BHUYA (1937) have shown three pairs of mesadenia and one pair of ectadenia in *Bruchus quadrimaculatus* and *Callosobruchus chinensis*, whereas, PAJNI (1968) has described one pair of mesadenia and three pairs of ectadenia in *C. maculatus*. However, SRIVASTAVA (1953) has mentioned only two types of glands in *Laria affinis*.

The glands of each side are named according to their location with respect to the vas deferens and ejaculatory duct in which they open (Figs. 1, 4 & 11). They are the anterior internal, anterior external, the lateral, the posterior external and the posterior internal glands.

The anterior internal is striaght except in *B. cassiae* (Fig. 1), *B. sahlbergi* and *B. pygomaculatus*, where it is curved. It is ectadenia (Fig. 11). The anterior external is straight and tubular in *B. flavovirens*; *B. lineolatus, B. urbanus;* curved in *B. sahlbergi, B. saundersi, B. maculipygus, B. multilineolatus* and *B. aureus* and coiled in *B. albizziae*. However, it is not represented in *B. minutus, B. vulgaris, B. angustifrons, B. cassiae, B. tephrosiae, B. andrewesi, B. mimosiae*, and *B. pygomaculatus*. It is an ectadenia gland.

The lateral is present in all the species and is two-lobed in *B. minutus, B. vulgaris, B. cassiae* (Figs. 1, 2), *B. angustifrons, B. tephrosiae*, and *B. andrewesi* and, four-lobed in the remaining species (Figs. 4, 12). It is a mesadenia gland (Fig. 13).

The posterior external again a straight tubular gland in *B. minutus, B. vulgris, B. tephrosiae* and *B. angustifrons;* curved in *B. cassiae, B. andrewesi, B. mimosiae*, and *B. pygomaculatus*. It is not represented in *B. sahlbergi, B. saundersi, B. maculipygus, B. lineolatus, B. flavovirens, B. dimorphous, B. multilineolatus, B. urbanus, B. aureus, B. albizziae* and *B. schilskyi*. The gland is ectadenia. The posterior internal is represented by all the members and also is ectadenia (Fig.11).

The above study reveals that the shape, number of testicular follicles and, shape, the number, and disposition of accessory glands are the higher characters of taxonomic promise. Further observations show that the grouping of the species on the basis of two- or four- lobed condition of the lateral gland, if combined with the observations on female reproductive system as well as the external morphological characters, the genus needs a split.

Acknowledgements :—The author is grateful to Professor G. L. ARORA, under whose guidance, the present work was carried out. My sincere thanks are due to Professor S. S. DHILLON for lab facilities. The help rendered by SH. MALKIAT SINGH is also acknowledged.

REFERENCES

BLATTER, P. (1897) Etude sur la structure histologique des glandes annexes de L'apparaeil de L'Hydrophili Berlese. *Archs Anat. microsc.*, **1**: 384–417.

BORDAS, L. (1900) Recherches sur les organes reproducteurs male des Coleopteres. *Annls Sci. nat.*, **2** : 283–448.

DAVIAULT, PAR LIONEL (1928) Study of the morphology of adult and instars. *Annls. Soc. ent. Fr.*, **97** : 205.

ESCHERICH, K. (1894) Anatomische Studien über das mannliche genital system der Coleopteren. *Z. Wiss. Zool.*, **57** : 620–642.

IMMS, A. D. (1957) A *General Text Book of Entomology* Methuen and Co., London.

KRAUSE, J. B. (1946) The structure of the gonads of the wood eating beetle *Passalus cornutus* FABR. *Ann. ent. Soc. Am.*, **30** : 193.

MUKERJI, D. & M. A. HAKIM BHYUA (1937) Reproductive system of the bruchid beetles *Bruchus quadrimaculatus* FABR., *Bruchus* (*Callosobruchus*) *chinensis* L. (Bruchidae-Coleoptera). *J. Morph.*, **61** : 175–214.

PAJNI, H. R. (1968) The development of the male genital ducts and the associated structures in *Callosobruchus maculatus* (F.) (Bruchidae : Coleoptera). *Res. Bull. Panjab Univ. Sci.*, **19** (1–2) : 81–88.

PARNELL, J. R. (1964) The structure and development of the reproductive organs of the two seed beetles *Apion fuscirotre* F. (Col. Curcul.) and *Bruchidius ater* (MARSH) (Col. Bruchidae). *Entomologist's mon. mag.*, **100** : 265–272.

SNODGRASS, R. E. (1935) *Principles of Insect Morphology*. New York and London.

SRIVASTAVA, U. S. (1953) Reproductive organs of certain stored grain beetles. II. male organs of *Laria affinis* and *Rhizopertha dominica*. *Proc. natn. Acad. Sci., India*, **23** : 46–65.

ZACHARUK, R. Y. (1958) Structure and functions of the reproductive systems of the Prairie grain wire worm, *Ctenicera aeripenis*. *Can. J. Zool.*, **36** : 726–751.

ZACHER, F. (1930) Untersuchugen zur Morphologie und Biologie der Samenkafer (Bruchidae-Lariidae). Beiträge zur kenntnis der Voratssched linge. 6. *Beiträge. Arb. Biol. Reichsanst. Land-u. Forst., Berlin*, **18** : 233–284.

Entomon, 1978, *Vol.* 3, *No.* 1, *pp.* 77 *to* 84

ANTENNA-CLEANING APPARATUS AND ITS EVOLUTIONARY TRENDS IN HYMENOPTERA

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(Received 28 July 1977)

The Antenna being the major sensory organ, antenna cleaning is functionally a very important activity. In apocritans this function is performed by a special device of the foreleg 'the antenna cleaning apparatus ' which consists of a modified and movable apical tibial spur and a corresponding concavity present on the basitarsus. In the lower symphytans, such as in Pamphiliidae, Xyelidae, Argidae, Cimbicidae and Diprionidae this apparatus occurs in a primitive state. In these families are seen two apical tibial spurs with no modification and with no corresponding concavity on the basitarsus. However, in Tenthredinidae the outer apical tibial spur is slightly modified while in Cephidae, Xiphydridae and Siricidae, there is present a single movable and modified apical tibial spur with a corresponding concavity which is in the form of only a small depression on the opposing surface of the basitarsus. In the various apocritans a corresponding depression on the basitarsus is further deepened while the tibial spur also becomes specially modified to make the apparatus more effective functionally. This apparatus has reached its climax of functional modification in the members of the Superfamily Apoidea.

(*Key words :* **antenna-cleaning apparatus, evolutionary trends, Hymenoptera)**

INTRODUCTION

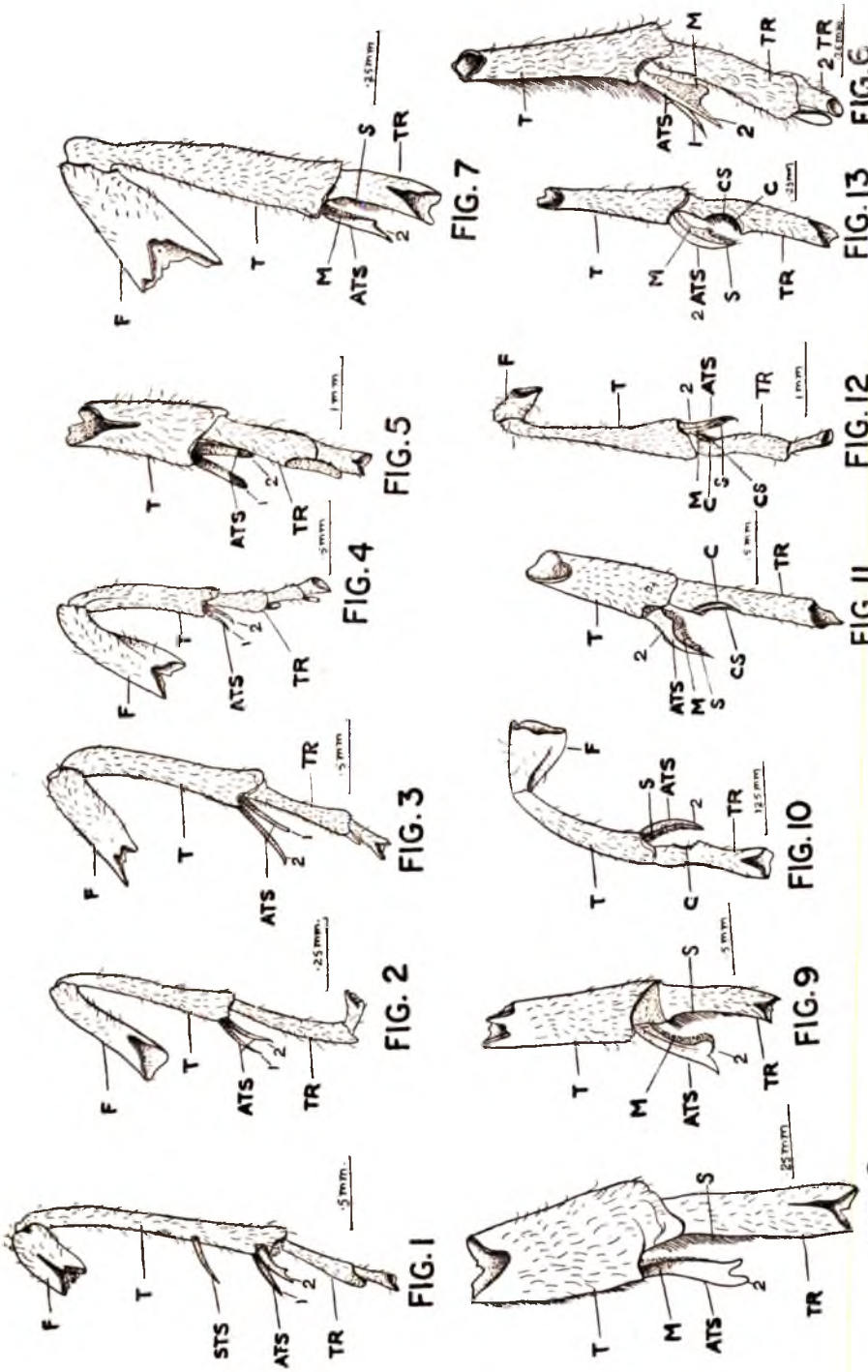
Very little work is available concerning the phylogenetic history of the antenna-cleaning apparatus of the Hymenoptera. Only GRINFEL'D (1952) has paid some attention to this aspect. SNODGRASS (1925), DUNCAN (1939), ALAM (1951), DHILLON (1966) and others have described the morphology of the apparatus in some details. Thus there is complete absence of such a study concerning a body feature constantly met with in the Hymenoptera. Therefore an attempt has been made here to present a coherent account of this structure in as many families of the Hymenoptera as possible and to trace the possible trends of its evolution in this order of insects.

MATERIAL AND METHODS

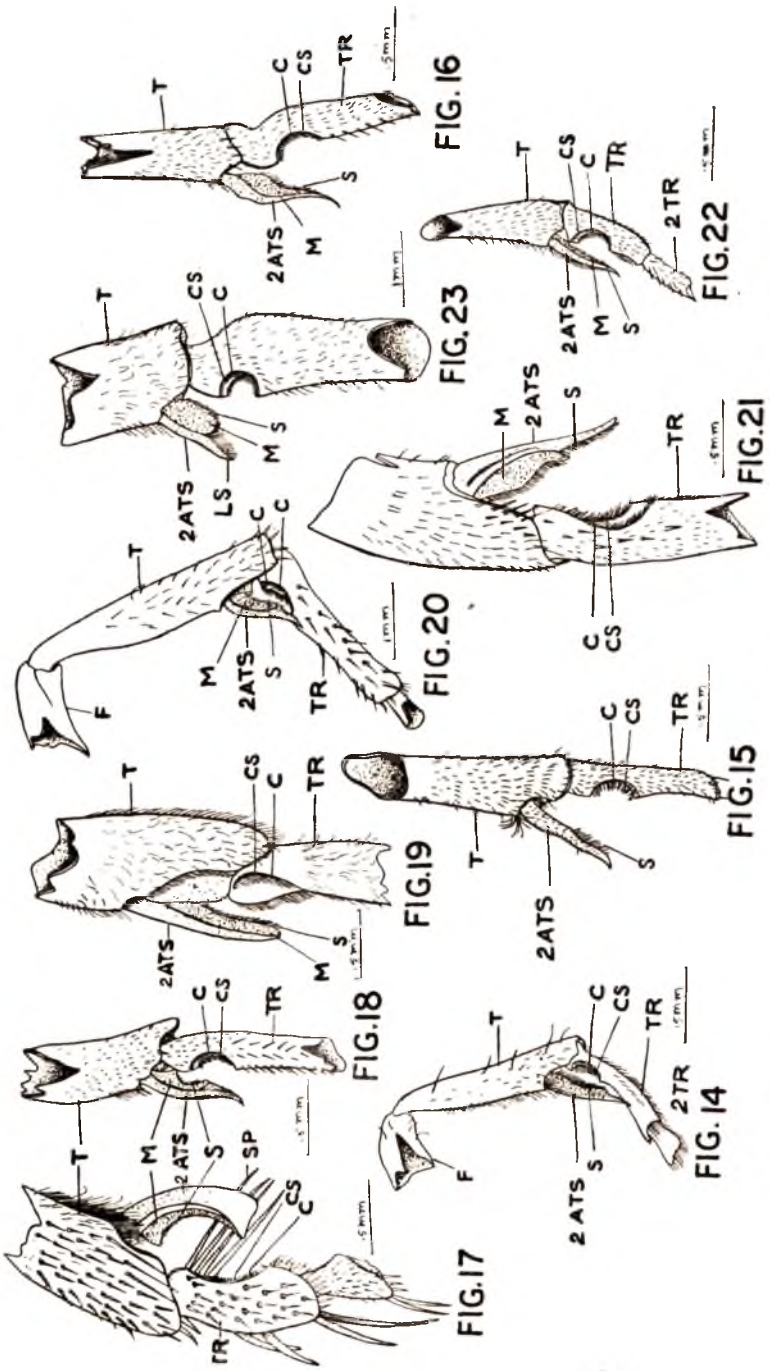
To carry out the present study most of the Apocrita were collected from the Punjab and the Himachal Pradesh during the months of September and October 1975 and preserved in 80% alcohol. However, Symphyta with the exception of Megalodontidae and Orrusidae, were supplied by the Biosystematic Research Institute, Canada, and Zoological Survey of India. As the specimens provided by them were in a dry state, they were softened by keeping them in 2% KOH for about six hours. Pigmented specimens were bleached with 0.5% KOH by keeping them in the latter for about 6 days. Diagrams were drawn with the help of binoculars fitted with graph eye-piece.

RESULTS AND DISCUSSION

The antenna being an important sensory organ, its cleanliness in insects is of great significance. GANGWERE (1958) noted that some lower orthopterans use a very primitive technique to clean the antenna. They make use of the maxillae and labial palps for this purpose whereas certain higher orthopterans make use of the foretarsi. In higher apocritans a portion of the foreleg is modified for cleaning the antennae. Similar condition has also been reported in the honey bee (SNODGRASS, 1925), in the wasps (DUNCAN,



Part of tibia and tarsus of proleg of : 1. *Acantholyda maculiventirs* ; 2. *Xyela bakeri* ; 3. *Arge clavicornis*; 4. *Neodiprion abietis* ; 5. *Cimbex americana americana* ; 6. *Tenthredo verticalis* ; 7. *Cephus* (*Cephus*) *cinctus* ; 8. *Xiphydria mellipes* ; 9. *Sirex cyaneus* ; 10. *Sycoscapter stabilis* ; 11. *Netelia kashmirensis*; 12. *Trachysphyrus* sp. ; 13. *Chrysis indogolea*.



14. *Sima rufonigra* ; 15. *Dorylus labiatus* ; 16. *Camponotus* nr *camelinus* ; 17. *Scolia quadripustulata* ; 18. *Scelephron* nr *intrudens* ; 19. *Eumenes dimidiatepennis* ; 20. *Calicurgus* sp. ; 21. *Vespa orientalis* ; 22. *Mutilla* sp. ; 23. *Xylocopa lemulscapa*.

ABBREVIATIONS USED

ATS—Outer apical tibial spur ; ATS—Inner apical tibial spur ; CA—Cavity ; CS—Cavity setae ; LS—Long setae ; MPD—Membranous pad ; S—Setae ; SP—Spines ; TR—Tarsus.

1939), in *Stenobracon deesae* (ALAM, 1951) and in the stinging hymenopterans in general (GRINFEL'D, 1962). The apparatus is commonly known as the antenna celeaning apparatus and consists of two main components: a specifically modified apical spur borne by the foretibia and a semicircular depression carved out on the basitarsus of the foreleg opposite the modified apical tibial spur. It may be of interest to know how and through which intermediate stages this apparatus came to acquire its existing form in the higher apocritans. An effort has been made to elucidate these possible intermediate stages in the sequence in which the modifications might have taken place.

The two components of the antenna cleaning apparatus work together, but their structural modifications have been separately described in the various families of the Order Hymenoptera.

Apical spurs of foretibia (Figs. 1 to 23)

The presence of two equal and similar apical spurs on the foretibia is the most primitive condition as found in case of *Neodiprion abietis* (Fig. 4) (Diprionidae), *Cimbex americana americana* (Fig. 5) and *Zarae inflata* (Cimbicidae). A similar condition occurs in *Diprion* and *Cimbex* (ARORA, 1953; 1956) and in *Abia* sp. (GRINFEL'D 1962). A slightly advanced condition is observed in *Xyela bakeri* (Xyelidae) (Fig. 2) and *Arge clavicornis* (Fig. 3) (Argidae) where although the spurs are of similar form, but of different lengths. This condition is also represented in *Arge* and *Megalodontes* (ARORA, 1956), in *Pteronidea* (GRINFEL'D, 1962), in *Pristiphora erichsonii* (WONG, 1963) and in *Athalia proxima* (DHILLON, 1966). In these insects the outer spur is shorter than its counterpart. *Pamphilius luteicornis, Acantholyda maculiventris* (Fig. 1) and *Cephalcia provancheri* all belonging to family Pamphiliidae represent a stage different than the above. In them, although the apical spurs are equal in size they look dissimilar. The outer spur is somewhat slenderer and the inner one is comparatively stouter and toothed. Similar condition has also been reported by RIVARD (1955) in *Cephalcia martinata,* and by GRINFEL'D (1962) in case of *Lyda, Pamphilius* and *Neurotoma.*

The next state of complexity in the series is represented by *Tenthredo verticalis* (Fig. 6) (Tenthredinidae) where, there are present two apical spurs which are of unequal length and are of dissimilar appearance. The inner spur is larger and thicker as compared to the outer one and is also forked at its apex. The tooth-like process faces the basitarsus. From the inner margin of this process there runs a thin and delicate membrane upto the base of the spur. This membranous pad serves to remove the foreign particles which adhere to the antenna during feeding. The second spur is present in a reduced state. Its function is not clear. Apical spurs of the same type have also been observed in some other members of family Tenthredinidae like *Pristiphora cincta, Pachyprotasis versicolor, Pachyprotasis brunetti* and *Tomostethus* (*Eutomostethus*) *assomensis.* ARORA (1956) and GRINFEL'D (1962) have described simiar condition of apical spurs in *Selandria* and *Rhogogaster* spp. respectively.

The members of family Xiphydridae present further advancement in the modification of spurs. As observed in case of *Xiphydria mellipes* (Fig. 7) only the inner spur is retained which is forked. The outer spur is completely missing. Perhaps this condition is quite suited to the function of antenna cleaning.

Better adaptations for antenna cleaning within the range of Suborder Symphyta is found in the members of family Cephidae and Siricidae. In case of *Cephus* (*Cephus*)

cinctus (Fig. 8) and *Sirex cyaneus* (Fig. 9) only the inner apical spur is retained whose morphological details resemble those of the inner spur of *Tenthredo verticalis*. However in *Sirex cyaneus* the tooth-like process of the spur which is directed towards the basitarsus is blunt and it bears a more pronounced membrane along its inner margin which is continuous with the entire inner surface of the spur. ARORA (1956) and GRINFEL'D (1962), in *Cephus* and *Urocerus* respectively have reported similar conditions of the spurs.

From the point of view of organisation in Order Hymenoptera, the Parasitica consisting of two important Superfamilies, i.e., Chalcidoidea and Ichneumonoidea, is placed in a higher scale of complexity than Symphyta. There, in case of *Sycoscapter stabilis* (Fig. 10) one of the members of Chalcidoidea, is present only one apical spur which shows slightly more advanced condition than is represented in the members of family Siricidae (Symphyta). Here the spur is not forked at its apex and instead it is curved along its inner margin. Opposite to the curved margin the surface of the basitarsus is also slightly depressed. Whenever the spur comes closer to the basitarsus an oval ring automatically appears between them. It is through this oval ring that the antenna is passed and moved for cleaning. The function of the membrane covering the inner margin of the spur is made more effective through the provision of microscopic setae present on it. They help to remove the extraneous particles adhering to the antenna much more effectively, than is possible in case of simple smooth membranous pad. The present authors have also observed the similar condition of the antenna cleaning spur in some other chalcids like *Sycophila decatomoides, Walkerella temeraria, Philotrypesis affinis* and *Blastophaga masoni*.

Slightly higher complexity in the series of these modifications is represented by the members of Superfamily Ichneumonoidea. In case of *Netelia kashmirensis* (Fig. 11) and *Trachysphyrus* sp. (Fig. 12), the spur bears the membranous pad with somewhat longer setae. The spur by itself is more curved than the spur of the chalcids. Similar condition has also been reported by GRINFEL'D (1962) in *Ophion* sp. However, ALAM (1951), in *Stenobracon deesae* (Braconidae) has reported two rows of bristles along the lateral margins of the inner side of the spur.

The members of family Chrysidae which are also parasites present a further advancement in the antenna cleaning device. The spur in *Chrysis indogolea* (Fig. 13) is curved against the curvature on the basitarsal surface as is the usual condition in other apocritans (mentioned above), but besides this there is another modification developed in the membranous pad of the spur, which in its apical half is further modified into an arc, the inner face of which is studded with conspicuous setae. The basal half of the spur which is away from the basitarsal curvature remains smooth. This modification has made the antenna cleaning ring slightly narrower but much more efficient in function.

In the members of families Mutillidae, and Formicidae as observed in case of *Mutilla* sp. (Fig. 22), *Dorylus labiatus* (Fig. 15) *Camponotus* nr *camelinus* (Fig. 16) and *Sima rufonigra* (Fig. 14), the condition of the spur almost resembles that seen in the members of Hymenoptera-Parasitica with only slight modifications.

In the members of the remaining families of Suborder Apocrita as observed in case of *Scolia quadripustulata* (Fig. 17) (Scoliidea), *Scelephron* nr *intrudens* (Fig. 18) (Sphecidae), *Vespa orientalis* (Fig. 21) (Vespidae), *Eumenes dimidiatepennis* (Fig. 19) (Eumenidae), *Calicurgus* sp. (Fig. 20), (Pompilidae), and *Xylocopa lemuiscapa* (Fig. 23) (Apoidae), conditions are further improved step by

step. At this stage on a casual look one can say that the spur has become specially modified for some specific function. In these series of modifications the highly specialized conditions are represented by the members of Superfamily Apoidea. As observed in the case of *Xylocopa lemuiscapa*, the spur is clearly divisible into two halves: the apical one with long, stout and prominent setae (Fig. 23) and the basal half with a well developed membranous pad having a growth of very fine setae. This portion of the spur lies opposite to the highly pronounced antenna cleaning cavity of the basitarsus and helps in the removal of fine pollen grains from the antenna. The distal half of the spur with long and stout setae, which do not directly form part of the antenna cleaning device, appear to help in the removal of coarser particles sticking to the antenna. This is probably the highly advanced stage which is reached through successive and minute modifications as discussed above.

Modifications leading to the formation of antenna cleaning cavity (Figs. 1–23)

The antenna cleaning cavity is the second component of the antenna cleaning apparatus. It is present on the inner side of the proximal end of the basitarsus. It has been observed in a highly developed form in case of the aculeatans but it is less developed in Hymenoptera-Parasitica and represented only in the form of a very shallow depression in some of the higher families of Suborder Symphyta. However, an attempt has here been made to trace the lineage of modification of the antenna cleaning apparatus in three hymenopteran groups.

In the primitive members of Suborder Symphyta which includes *Acantholyda maculiventris* (Fig. 1), *Pamphilius luteicornis, Cephalcia provancheri* (Pamphiliidae), *Xyela bakeri* (Fig. 2) (Xyelidae), *Arge clavicornis* (Fig. 3) (Argidae), *Neodiprion abietis* (Fig. 4) (Diprionidae), *Cimbex americana americana* (Fig. 5) and *Zarae inflata* (Cimbicidae), the antenna cleaning apparatus is represented only by the apical spurs of the tibia and to match these no form of cavity, shallow or deeper, is present. A similar condition is also reported to occur in many other primitive symphytans, e.g., *Diprion polytomum* (REEKS, 1937), *Diprion, Cimbex, Arge* and *Magalodontes* (ARORA, 1956), *Cephalcia marginata* (RIVARD, 1955) and in *Lyda, Pamphilius* and *Neurotoma* (CRINFEL'D, 1962).

Slight advance over this condition is indicated in the members of the family Tenthredinidae. For example in case of *Tenthredo verticalis* (Fig. 6), the inner face of the proximal end of the basitarsus is slightly concave which occurring opposite the modified apical tibial spur and along with it forms an oval ring through which the antenna is drawn to remove the pollen grains and other foreign particles adhering to it. A similar condition is also noted in many other tenthredinids like *Pristiphora cincta, Tachyprotasis versicolor, P. brunetti* and *Tomostethus* (*Eutomostethus*) *assomensis*. The occurrence of similar conditions has also been reported by DHILLON (1966), in *Athalia proxima*.

The next stage is represented by *Cephus* (*Cephus*) *cinctus* (Fig. 7) (Cephidae), *Xiphydria mellipes* (Fig. 8) (Xiphydridae) and *Sirex cyaneus* (Fig. 9) (Siricidae). In these insects the mesal concavity near the proximal end of the basitarsus is also provided with a rich growth of long setae which work like a brush to remove the extraneous particles of dust and pollen grains. This shallow dug-out lined with long setae, can be taken as a predecessor of the properly carved out antenna cleaning cavity found in higher apocritans. GRINFEL'D (1962) has also mentioned a similar condition in case of *Trachelus tabidus*.

The degree of improvement in the antenna cleaning apparatus increases further in the members of Hymenoptera-Parasitica. In *Sycoscapter stabilis* (Fig. 10), a representative from Superfamily Chalcidoidea, there exists a shallow depression on the basitarsus which can be taken as an antenna cleaning cavity. On the other hand it is devoid of any kind of setae, membrane or ridge. It exactly corresponds to the single movable apical spur which is recurved and is also provided with a row of setae which probably compensate for what is lacking on the basitarsal depression. Similar condition has also been noted by the present authors in some other chalcids like *Blastophaga masoni* (Agaonidae), *Philotrypesis affinis* (Torymidae), *Micranisa pteromaloides* (Torymidae) and *Sycophila decatomoides* (Eurytomidae).

A slight advance over the above mentioned condition is shown by the members of Superfamily Ichneumonoidea. In case of *Netelia kashmirensis* (Fig. 11) and *Trachysphyrus* sp. (Fig. 12) the two representatives of this Superfamily, the antenna cleaning concavity has deepened further. The lateral margins of this concavity are lined with thick setae. The presence of these setae is an additional provision in the members of this Superfamily and it helps in the more efficient functioning of this apparatus. A similar condition has also been reported by ALAM (1951) in *Stenobracon deesae* and by GRINFEL'D (1962) in case of *Ophion* sp.

In case of *Chrysis indogolea* (Fig. 13) (Chrysidae) this modification has been improved further on account of the deepening of the basitarsal concavity. Besides, the lateral sides of the concavity are provided with two rows of setae which act as brushes.

In the members of the families like Mutillidae and Formicidae represented by *Mutilla* sp. (Fig. 22) (Mutillidae), *Sima rufonigra* (Fig. 14), *Camponotus* nr *camelinus* (Fig. 16) and *Dorylus labiatus* (Fig. 15) (Formicidae), the above condition improves still further due to the further deepening of the concavity which takes the form of a distinct cavern.

In *Scolia quadripustulata* (Fig. 17) belonging to the family Scoliidae, there is seen another clear divergence from the previous condition. In this case four long spines have been observed near the proximal margin of the concavity, which are even longer than the entire length of the basitarsus. The authors have observed that in the living *Scolia* these spines enhance the efficiency of the cleaning process. It is probably a secondary character acquired by this insect only. Besides these bristles, the concavity bears a double row of short bristle like setae.

In the members of the other higher families like, *Scelephron* nr *intrudens* (Fig. 18) (Sphecidae), *Stizus vespiformis* (Sphecidae), *Eumenes dimidiatepennis* (Fig. 19) (Eumenidae), *Vespa orientalis* (Fig. 21) (Vespidae) and *Calicugus* sp. (Fig. 20) (Pompilidae) the basitarsal concavity is seen as a somewhat semicircular cavern with its edges provided with large number of setae which effectively serve the antenna cleaning function.

Further in *Xylocopa lemuiscapa* (Fig. 23) (Apoidea) the antenna cleaning cavity has reached the climax of perfection. It is very deep, rather in the form of a hollowed out chamber which is provided with a double row of small bristles. Similar condition has also been reported by SNODGRASS (1925) in honey bee.

Acknowledgements:— We are grateful to the Director, Commonwealth Institute of Entomology, London, and to Dr. V.K. GUPTA of Delhi University, Delhi, for identifying some of the hymenopterans required for this study. It is our special pleasure to acknowledge the kind co-operation given by the Biosystematic Research Institute, Canada, and

the Zoological Survey of India, Calcutta, for supplying us some of the badly needed specimens for the preparation of this papaer.

REFERENCES

ALAM, S. M. (1951) The skeleto-muscular mechanism of *Steenobracon deesae* CAM. (Braconidae Hymenoptera) – an ectoparasite of sugarcane and juar borers of India. Part I. Head and thorax. *Aligarh Musl. Univ. Publs Zool. Ser. Ind. Ins. Typ.*, **3**(1) : 74 pp.

ARORA, G. L. (1953) The external morphology of *Diprion pini* L. (Symphyta, Hymenoptera). *Res. Bull. E. Punjab Univ., Hoshiarpur. Zool.*, **25** : 1–21.

ARORA, G.L. (1956) The relationship of the Symphyta to other orders of insects on the basis of adult external morphology. *Res. Bull. E. Punjab Univ., Hoshiarpur, Zool.*, **90** : 85–119.

DHILLON, S. S. (1966) The morphology and biology of *Athalia proxima* (Tenthredinidae, Hymenoptera). *Aligarh. Musl. Univ. Publs. Zool. Ser. Ind. Ins. Typ.*, **7** : 165 pp.

DUNCAN, C. D. (1939) A contribution to the biology of North American vespine Wasps. *Stanford Univ. Publs. Biol. Sci.*, **8**(1) : 272 pp.

GANGWERE, S. K. (1958) Grooming behavior in Orthoptera. *Entomol. News.*, **69** (5) : 123–128.

GRINFEL'D, E. K. (1962) Rise and development of the device for the collection of pollen in bees (Hymenoptera-Apoidea) (In Russian with English summary). *Ent. Obozr.* Moscow, **41** : 65–75.

REEKS, W. A. (1937) The morphology of the adult of *Diprion polytomum* (HARTIG). *Canad. Ent.*, **69** : 257–264.

RIVARD, I. (1955) Contribution to the morphology of the pine webspinning sawfly *Cephalcia marginata* MIDDLEKAUFF (Hymenoptera : Pamphiliidae). *Can. Ent.*, **87** : 382–399.

SNODGRASS, R. E. (1925) *Anatomy and Physiology of Honey-bee.* MacGraw Hill Book Co., New York.

WONG, H. R. (1963) The external morphology of the adult and ultimate larval instar of the larch sawfly. *Pristiphora erichsonii* (HTG.) (Hymenoptera : Tenthredinidae). *Can. Ent.*, **95** : 897–921.

Entomon, 1978, *Vol.* 3, *No.* 1 *pp.* 85 *to* 90

DROSOPHILA FAUNA OF BABABUDANGIRI AND KEMMANGUNDI HILL RANGES (WESTERN GHATS)

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(Received 4 July 1977)

The preliminary survey of *Drosophila* fauna made in 12 spots at various altitudes of Bababudangiri and Kemmangundi hill ranges of Western Ghats yielded 2415 flies comprising 22 species of which 21 species belong to the genus *Drosophila* and one species to the genus *Scaptomyza* indicating the preponderance of the members of the genus *Drosophila*. Of the 21 species of the genus *Drosophila* 14 belong to the subgenus *Sophophora*, five to the subgenus *Drosophila* and two to the subgenus *Scaptodrosophila*. The collection data reveal the presence of four new species, two of which are named *D. giriensis* and *D. gundensis* and described elsewhere, while the other two new species have been tentatively named species 'U' and species 'N'. Among the *Drosophila* species collected some were found to be abundant in some localities and absent in other localities, while the majority of them exhibited a patchy distribution indicating the variations in the composition and relative numbers of *Drosophila* species between localities. The evaluation of the data reveals that majority of the members collected belong either to the *melaogaster* species group of the subgenus *Sophophora* or to the *immigrans* species group of the subgenus *Dropsophila*. The variability in the relative concentrations and the distributional pattern of *Drosophila* species in the area under study as well as the ecological dominance of the members of the *melanogaster* and *immigrans* species groups belonging to two subgenera are discussed.

(*Key words : Drosophila, Scaptomyza,* **relative concentration, distributional pattern, ecological dominance**)

INTRODUCTION

The knowledge on the systematics and distribution of *Drosophila* fauna of Indian subcontinent is fragmentary, in spite of the striking progress made during the last few years (Parshad and Paika, 1964; Parshad and Duggal, 1965; Gupta and Ray-Chaudhuri, 1970; Sreerama Reddy and Krishnamurthy, 1971, 1974, 1976; Vaidya and Godbole, 1971, 1972, 1973, 1976; Siddaveere Gowda and Krishnamurthy, 1972; Ranganath and Krishnamurthy, 1972; Gupta, 1974). Reference to literature reveals that very little information is available on the varied aspects of *Drosophila* and a vast area of the Indian subcontinent still awaits exploration. However, the subcontinent is too vast to get a complete picture of *Drosophila* fauna. Hence only a part of peninsular India, viz., Western Ghats has been chosen for a detailed investigation as to the ecology, distribution and systematics of *Drosophila* fauna. The Western Ghats include the humid belt of hilly or mountainous country extending along the western side of peninsular India from the mouth of river Tapti to Cape Comorin. It is an important part of the monsoonland, where the vegetation is influenced more by the abundance and distribution of seasonal rainfall than the atmospheric temperature. The western side of the Western Ghats is on the threshold of south west monsoon and receives a rainfall of 203-254 cm, and the eastern side lies in the rain shadow area of the peninsula. The Western Ghats have been divided into four

phytogeographical regions, viz., (1) the Western Ghats from the river Tapti to Goa, (2) the Western Ghats from the river Kalinadi to Coorg, (3) the Nilgiri and (4) the Anamalai, Palani and Cardamom Hills (Subramanyam and Nayar, 1974). As a part of the project, the authors have initially selected Bababudangiri and Kemmangundi hill ranges lying in the second region of Western Ghats and the results of the preliminary survey made are presented here.

MATERIALS AND METHODS

Drosophila collection was undertaken during the middle of monsoon period in the month of September, 1976. The flies were collected from 12 localities with variable altitudes ranging from 1000 to 1600 m. Usual trapping method was employed by using 250 ml milk bottles with ripe banana mash sprayed with a few drops of yeast solution. Bottles containing bait were tied up to the branches of trees and bushes in shaded cool uninhabited valleys and rivulets with more or less moist surroundings. Two days after the exposure of the bait, they were collected in the cooler hours of the day. Net sweeping was also done occasionally where rotten fruits and other organic material were abundant. The collected flies were etherised, categorised and the number of each species were recorded. The individual females, which could not be assigned to definite species were isolated and allowed to breed in separate media vials. The progenies of such single gravid female were used for detailed morphological, anatomical and cytological investigations to assign them to their respective groups.

OBSERVATIONS

The collections made in 12 spots at different altitudes of Bababudangiri and Kemmangundi hill ranges yielded a total of 2415 flies comprising 22 species, of which 21 species belong to the genus *Drosophila* and one to the genus *Scaptomyza*. The 21 species of the genus *Drosophila* which are assigned to their respective subgenera along with the representative member of the genus *Scaptomyza* are listed below:

Genus: *Drosophila*

(a) Subgenus: *Sophophora* Sturtevant, 1939

D takahashii Sturtevant, 1927; *D. giriensis* Prakash and Reddy, 1977; *D. suzukii* Matsumura, 1931; *D. eugracilis* Duda, 1924; *D. ananassae* Doleschall, 1858; *D. bipectinata* Duda, 1923; *D. malerkotliana* Prashad and Paika, 1964; *D. punjabiensis* Parshad and Paika, 1964; *D jambulina* Parshad and Paika, 1964; *D. mysorenis* Reddy and Krishnamurthy, 1970; *D. anomelani* Reddy and Krishnamurthy, 1973; *D. gundensis* Prakash and Reddy, 1977; *D. rhopaloa* like; Species '*U*'[1].

(b) Subgenus: *Drosophila* Fallen 1823.

D. nasuta Lamb, 1914; *D. neonasuta* Sajjan and Krishnamurthy, 1975; *D. immigrans* Sturtevant, 1921; *D brindavani* Rajeshwari and Krishnamurthy, 1971; *Species* '*N*'[1].

(c) Subgenus: *Scaptodrosophila,* Duda, 1923

D. meijerei indicus Rajeswari and Krishnamurthy, 1971; *D. mundagensis* Sajjan and Reddy, 1975.

Genus: *Scaptomyza* Hardy, 1849

Scaptomyza elmoi Takada (Personal communication from Prof. T. Okada, 1977.

The occurrence, distributional pattern and the relative numbers of each of the 21 species of *Drosophila* collected in 12 localities along with their altitude are shown in Table 1. The number of individuals of different species varies from as low as one to as high as 581. The latter figure is for *D. immigrans* which constitutes 24.05% of the population of *Drosophila* collected in this area. The next higher number is for *D. nasuta* with a total of 486 or nearly 20.12 % of the population. Both these species are found to be associated

[1] New species to be described.

TABLE 1. Distribution of different species of *Drosophila* in Bababudangiri and Kemmangundi hill ranges (Western Ghats).

Localities	1	2	3	4	5	6	7	8	9	10	11	12
Altitude in metres	1000	1050	1250	1250	1250	1300	1325	1350	1375	1375	1500	1600
1. *D. takahashii*	24	—	—	39	—	—	—	—	—	—	—	—
2. *D. giriensis*	18	—	45	—	18	—	—	13	50	13	—	—
3. *D. suzukii*	—	—	—	—	—	—	1	—	—	—	—	—
4. *D. eugracilis*	36	—	—	26	—	—	—	—	48	—	—	—
5. *D. ananasae*	—	—	—	—	—	—	—	8	—	—	—	—
6. *D. bipectinata*	—	—	—	—	9	—	22	—	17	—	—	—
7. *D. malerkotliana*	26	—	—	32	29	15	19	—	50	49	—	—
8. *D. punjabiensis*	—	—	17	—	—	—	—	—	8	—	—	—
9. *D. jambulina*	9	—	—	—	—	3	—	6	—	—	—	—
10. *D. mysorensis*	18	35	53	24	19	27	29	20	67	38	30	23
11. *D. anomelani*	21	25	—	—	—	—	—	—	—	—	—	—
12. *D. gundensis*	—	—	—	—	—	4	—	—	—	4	—	—
13. *D. rohopaloa* like	—	18	—	28	24	20	—	18	48	20	—	—
14. Species '*U*'[1]	—	—	—	—	—	—	—	—	—	—	—	1
15. *D. nasuta*	65	38	68	26	46	10	44	29	72	20	38	30
16. *D. neonasuta*	—	—	—	—	4	—	—	—	8	—	—	—
17. *D. immigrans*	23	44	—	37	43	79	81	47	54	29	115	29
18. *D. brindavani*	—	—	—	—	—	—	6	—	—	—	—	—
19. Species '*N*'[1]	—	—	—	—	—	—	—	—	—	11	—	—
20. *D. meijcrei indicus*	—	—	—	—	—	—	—	—	—	1	—	—
21. *D. mundagensis*	37	16	—	—	—	—	—	—	—	—	—	—
22. *Scaptomyza elmoi*	—	—	—	—	—	—	1	—	—	—	—	—
Total number of individuals	277	176	183	212	192	158	203	141	422	185	183	83
Total no. of species	10	6	4	7	8	7	8	7	10	9	3	4

[1] New species to be described.

with the moist and humid climatic conditions which are favourable for the colonization of these species. The other common species in this area are *D. mysorensis* (383 or 15.85%), *D. malerkotliana* (220 or 9.10%), *D. rhopaloa* like (176 or 7.28%) and *D. giriensis* sp. nov. (157 or 6.50%). These four species together with the less common species such as *D. eugracilis, D. ananassae, D. takahashii D. bipectinata, D. punjabiensis, D. jambulina,*

D. anomelani, D. gundensis sp. nov., *D. suzukii* and species '*U*' belonging to *melanogaster* species group of the subgenus *Sophophora* constitute nearly 52.33% of the entire population of this area. The other two common species like *D. immigrans* and *D. nasuta* together with *D. neonasuta, D. brindavani* and species '*N*' belonging to *immigrans* species group of subgenus *Drosophila* constitute nearly 45.38%, while the remaining 2.23% of the population is shared by two species *D. meijerei indicus* and *D. mundagensis* belonging to the subgenus *Scaptodrosophila.*

The differences with regard to the number and the composition of *Drosophila* species between the localities under study are a common feature. For instance, localities 1 and 9 yielded a total of 277 and 422 individuals respectively comprising 10 different species. The localities 3 and 11 yielded a total of 183 individuals each consisting of four and three species respectively, while the locality 12 yielded only 83 individuals having four species. The remaining localities were found to be quite variable having 141 to 212 individuals consisting of six to nine species.

The most interesting feature of the collection record is that the majority of the members collected belong either to the *melanogaster* species group of the subgenus *Sophophora* or to the *immigrans* species group of the subgenus *Drosophila* indicating the ecological dominance of the members of these two species groups belonging to two different subgenera.

DISCUSSION

Bababudangiri and Kemmangundi hill ranges, a part of the second phytogeographical region of Western Ghats which is under investigation constitute a vast unexplored area so far as *Drosophila* is concerned. The climatic and physiographic conditions of the area with its luxuriant flora and running water streams during most part of the year offer an excellent abode for the colonization of several *Drosophila* species.

It is well known that *Drosophila* species are not evenly distributed in nature. Their occurrence and distribution is largely determined by several ecological factors such as temperature, humidity, rainfall, vegetation, availability of food etc. The numerical variation of different species in a population and between populations is a common feature. In our present study the 12 localities chosen in the two hill ranges of Bababudangiri and Kemmangundi exhibit more or less similar general habitats except for the differences in altitudes. In spite of the similarities in the general habitat it is found that these localities vary significantly not only in the faunal constellation of species but also in the number of individuals of different species. The differences in the composition of *Drosophila* species between the localities may be accounted for the differences in the microecological factors. In addition, the distribution and abundance of species not only depends on the colonizing or invasive abilities of a species but also on the ecological relationships of the species concerned. For instance, the members of the *immigrans* species group such as *D. immigrans* and *D. nasuta* have been recorded in large numbers in certain localities characterised by moist and humid climatic conditions. This is in conformity with the earlier observations of Ranganath and Krishnamurthy (1972) and Sreerama Reddy and Krishnamurthy (1974).

Sreerama Reddy and Krishnamurthy (1974) have pointed out the abundance of the members belonging to *melanogaster* species group or to the *immigrans* species group in their collections from the gardens and orchards around Mysore city, Nilgiri and

Palani Hills. Similarly, the present study on the *Drosophila* fauna of Bababudangiri and Kemmangundi hill ranges of Western Ghats reveals the dominance of the above two species groups in almost all the localities scanned. However, certain other species such as *D. meijerei indicus* and *D. mundagensis* were found occasionally in the collections. Further, it is clear from the present study that the members of the *melanogaster* species group in particular are versatile as evidenced not only by their large numbers but also in the variety of species. Thus the present report on the *Drosophila* fauna of Western Ghats is in conformity with the suggestion of Bock and Wheeler (1972), who regarded the Indian sub-continent as the general area for the origin of *melanogaster* species group and South East Asia in general, for the origin and wide speciation for both *melanogaster* and *immigrans* species groups. Incidentally, the finding of three new species belonging to *melanogaster* species group and one new species belonging to *immigrans* species group supports the suggestion of Bock and Wheeler (1972) and corroborates the findings of Sreerama Reddy and Krishnamurthy (1974).

Subramanyam and Nayar (1974) have pointed out that the Western Ghats behave like an oceanic island in the development of endemic species of plants as it is protected by sea on western side, Vindhya and Satpura on northern side and semiarid Deccan plateau on eastern side. Similarly, the present study on the *Drosophila* fauna of Western Ghats reveals the occurrence of several new forms indicating that it not only acts as a nursery ground for speciation of *Drosophila* but also as a centre for the development of endemic species because of its geographic position.

Acknowledgements:— The authors are grateful to Prof. M. R. Rajasekarasetty, Department of Zoology, Manasa Gangotri, Mysore, for providing necessary facilities and constant encourgement to carry out the work. One of us (HSP) is thankful to the University of Mysore for awarding a Junior Research Fellowship.

REFERENCES

BOCK, I. R. & M. R. WHEELER (1972) The *Drosophila melanogaster* species group. *Univ. Tex. Publs.* 7213 : 1–102.

GUPTA, J. P. (1974) The family Drosophilidae in India. *Indian Biologist*, **5** : 7–30.

GUPTA, J. P. & S. P. RAY-CHAUDHURI (1970) Some new and unrecorded species of *Drosophila* (Diptera : Drosophilidae) from India. *Proc. R. ent. Soc. Lond.*, **39B** : 57–72.

PARSHAD, R. & K. K. DUGGAL (1965) Drosophilidae of Kashmir, India. *Drosoph. Inf. Serv.*, **40** : 44.

PARSHAD, R. & I. J. PAIKA (1964) Drosophilid survey of India. II. Taxonomy and Cytology of the subgenus *Sophophora* (*Drosophila*). *Res. Bull. Punjab. Univ. Sci.*, **15** : 225–252.

RANGANATH, H. A. & N. B. KRISHNAMURTYHY (1972) Preliminary survey of *Drosophila* in Biligirirangana Hills (Mysore State, India). *Drosoph. Inf. Serv.*, **48** : 132.

SIDDAVEERE GOWDA, L. & N. B. KRISHANAMURTHY (1972) Report of *Drosophila* species in Charmadi Ghats. *Drosoph. Inf. Serv.*, **48** : 38.

SREERAMA REDDY, G. & N. B. KRISHARAMURTHY (1971) Preliminary survey of Drosophilids in Nilgiris and Kodaikanal ranges. *Drosoph. Inf. Serv.*, **47** : 116.

SREERAMA REDDY, G. & N. B. KRISHNAMURTHY (1974) Systematics and distribution of *Drosophila* fauna of South India. *J. Mysore. Univ.*, **26B** : 54–64.

SREERAMA REDDY, G. & N. B. KRISHNAMURTHY (1976) Distribution of different species of *Drosophila* in Jogimatti Hills, Chitradurga District, Karnataka, India. *Drosoph. Inf. Serv.*, **52** : 105.

SUBRAMANYAM, K. & M. P. NAYAR (1974) Vegetation and Phytogeography of the Western Ghats, 178–196, *in : Ecology and Biogeography in India*. Dr. W. Junk b. v. Publishers, The Hague.

VAIDYA, V. G. & N. N. GODBOLE (1971) Systematic study of Drosophilidae in Poona and neighbouring areas. I. *J. Univ. Poona.*, **40** : 49–61.

VAIDYA, V. G. & N. N. GODBOLE (1972) Systematic study of Drosophilidae in Poona and neighbouring areas. II. *J. Univ. Poona*, **42** : 93–94.

VAIDYA, V. G. & N. N. GODBOLE (1973) Systematic study of Drosophilidae in Poona and neighbouring areas. III. *J. Univ. Poona*, **44** : 41–43.

VAIDYA, V. G. & N. N. GODBOLE (1976) Systematic study of Drosophilidae in Poona and neighbouring areas. IV. *J. Univ. Poona*, **48** : 85–92.

Entomon, 1978, *Vol.* 3, *No.* 1, *pp.* 91 *to* 94

SOME PARASITES AND PREDATORS OF APHIDS FROM NORTHEAST INDIA AND BHUTAN

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This paper reports 4 species of hymenopteran parasites, 18 species of insects and 5 species of spiders as predators of aphids from northeast India and Bhutan. Some of these parasites are reported newly from some hitherto unreported aphid host. Seven insects and all spider species are newly reported as predators of some aphids. Besides, eight insect species have been found to predate on seven hitherto unreported aphid host species.

(*Key words :* **Parasites and predators of aphids**)

During the course of recent surveys for aphids in Northeast India and Bhutan, some aphid parasites and predators were collected. Ten of the predators were found to be coleopteran, seven dipteran, one hemipteran and five belonging to order Araneida under the class Arachnida and all the four parasites were found to be hymenopteran insects. A few of the parasites and predators could not be determined upto species level at the moment. One (*) mark has been used to those, which are found to be new record from India and two (**) marks indicate new host for the respective parasites and predators. It is interesting to point out that for the first time different spider species are reported here as predators. In this connection, it may be mentioned that previous reports concerning aphid parasites and predators from this part of the country are found in C.I.B.C. Final Technical Report, U. S. PL 480 Project (1964–1969), in works of Nath and Sen (1976) and Stary and Ghosh (1975). Aphid parasites and predators along with necessary data are listed below. Examples of the parasites and the predators are in the collection of Entomology Laboratory, Department of Zoology, University of Calcutta.

APHID PARASITES

1. **Aphelinus** sp.

   Host: ***Macrosiphum rosae* (L.) from *Rosa cania*, 12.v.1976, Kalimpong, West Bengal; ***Macrosiphum* (*Sitobion*) *rosaeiformis* Das from *Rosa* sp. 25.v.1976, Moirang, Manipur.

So far, 8 species have been reported under the genus from India by Ramaseshiah and Dharmadhikari (1969).

2. **Ephedrus plagiator** (Nees)

   Host: ***Macrosiphum rosae* (L.) from *Rosa cania*, 12.v.1976, Kalimpong, West Bengal.

This species is known to parasitize a number of aphids in Northeast India.

3. **Pauesia indica** Stary

   Host: *Lachnus tropicalis* (v.d. Goot) from *Litsea sebifera*, 22.vi.1976, Churachandpur, Manipur.

4. **Trioxys indicus** Subba Rao and Sharma

   Host: *Aphis craccivora* Koch from *Vicia faba*, 10.v.1976, Moirang, Manipur; *Aphis gossypii* Glover from *Colocasia* sp., 16.v.1976; from *Psidium*

guava, 20. v. 1976, Moirang, Manipur.

This species has been reported by Narayanan, Subba Rao and Sharma (1958) and Shuja Uddin (1973) from North India.

APHID PREDATORS

Order : Coleoptera.
Family : Coccinellidae.

1. ***Ballia** sp.

Host: *Tuberolachnus salignus* (Gmelin) from *Salix* sp., 14.xi.1976, Thimpu, Bhutan. Predatory stage: Both grub and adult.

2. **Coccinella septempunctata** L.

Host: ***Taoia indica* (Ghosh and Raychaudhuri) from *Alnus nepalensis*, 26.v.1976, Kalimpong, West Bengal.

Predatory stage: Both grub and adult.

This species has previously been reported by Aziz, Hyder and Ali (1969) from South India: Saxena, Sirkar and Phokela (1970) and Rao (1969) from North India.

3. **Coelophora sexareata** Muls.

Host: ***Taoia indica* (Ghosh and Raychaudhuri) from *Alnus nepalensis*, 26.v.1976, Kalimpong, West Bengal.

Predatory stage: Both grub and adult.

This species has been reported to feed on aphids on *Artemisia vulgaris* from Gauhati, Assam by Rao (1969).

4. ***Cryptogonus quadriguttatus** (Ws)

Host: *Melanaphis sacchari* (Zehntner) from *Zea mays*, 7.vii.1976, Kalimpong, West Bengal.

Predatory stage: Both grub and adult.

5. ***Epilachna vigintioctopunctata** (F.)

Host: *Aphis spiraecola* Patch from *Solanum nigrum*, 29.iv.1976, Dimapur, Nagaland.

Predatory stage: Only grub.

6. **Menochilus sexmaculatus** (F.)

Host: ***Brachycaudus helichrysi* (Kotb.) from *Eupatorium odoratum*, 29.iv. 1976, Dimapur, Nagaland.

Predatory stage: Only grub.

7. **Oenopia sauzeti** Mls.

Host: ***Macrosiphoniella pseudoartemisiae* Shinji from *Chrysanthemum coronarium*, 10.vii.1976, Kalimpong, West Bengal.

Predatory Stage: Both grub and adult.

8. ***Oenopia luteopustulata** Mls.

Host: *Macrosiphum* (*Sitobion*) *rosaeiformis* Das from *Rosa cania*, 25.x.1976, Kalimpong, West Bengal.

Predatory stage: Both grub and adult.

9. **Pullus pyrochellus** (Muls)

Host: *Aphis gossypii* Glover from *Psidium guava*, 20. v. 1976, Moirang, Manipur; ***Macrosiphum* (*Sitobion*) *rosaeiformis* Das from an unidentified plant. 22.vi.1976, Churachandpur, Manipur.

Predatory stage: Both grub and adult.

This predator has been reported from south and eastern India by Rao (1969).

10. **Synonycha grandis** (Th.)

Host: *Paraoregma alexandri* (Takahashi) from *Bambusa* sp., 9.vii.1976, Kalimpong, West Bengal.

Predatory stage: Both grub and adult.

Order: Diptera
Family : Calliphoridae

11. ***Calliphora paltoni** Aub.

Host: *Paraoregma alexandri* (Takahashi) from *Bambusa* sp., 7.vii.1976, Kalimpong, West Bengal.

Family: Syrphidae

12. **Ischiodon scutalaris** F.

Host: ***Aphis spiraecola* Patch from *Artemisia vulgaris*, 19.vi.1976 Loktak, Manipur.

This species has earlier been reported by Saxena, Sirkar and Phokela (1970) from North India.

13. ***Paragus indicus** Brun.

Host: *Aphis spiraecola* Patch from *Bidens pilosa*, 26.vi.1976, Kalimpong, West Bengal.

14. Paragus serratus F.

Host: *Aphis craccivora* Koch from *Vicia faba*, 10.v.1976, Moirang, Manipur.

This species has previously been reported by Vadivelu, Mohanasundaram and Subba Rao (1975) from South India and by Rao (1969) from north and eastern India besides South India.

15. Sphaerophoria javana Wied.

Host: *Macrosiphum (Sitobion) rosaeiformis* Das from *Rosa* sp., 4.v.1976, Moirang, Manipur.

16. Syrphus balteatus de Geer

Host: ***Melanaphis sacchari* (Zehntner) from *Zea mays*, 6.vii.1976, Kalimpong, West Bengal; *Macrosiphum (Sitobion) rosaeiformis* Das from *Rosa* sp., 4. v. 1976, Moirang, Manipur.

17. Syrphus serareus Wied

Host: ***Macrosiphum rosae* (L.) from *Rosa cania*, 28.iv.1976, Kalimpong, West Bengal.

In all cases of dipteran predators only larvae were found to feed on aphids.

Order: Hemiptera
Family: Anthocoridae

18. ***Bilia** sp.

Host: *Greenidea (Trichosiphum) formosana heeri* Raychaudhuri, Ghosh, Banerjee and Ghosh (Ms. name) from *Psidium guava*, 8.i.1976, Kalimpong, West Bengal.

Predatory stage: Adult bug.

Order: Araneida
Family: Araneidae

19. ***Araneus** sp.

Host: *Aphis gossypii* Glover from *Capsicum frutescence*, 26.xii.1976, Mangan, Sikkim; *Macrosiphum rosae*, (L.) from *Rosa* sp., 28.xii.1976, Gangtok, Sikkim, from *Rosa* sp., 8.i.1977, Kalimpong, West Bengal; *Macrosiphum (Sitobion) rosaeiformis* Das from *Rosa* sp., 28.xii.1976, Gangtok, Sikkim.

20. ***Cyclosa** sp.

Host: *Macrosiphum (Sitobion) rosaeiformis* Das from *Rosa* sp., 30.xii.1976, Singtam, Sikkim; from *Rosa* sp., 8.i.1977, Kalimpong, West Bengal.

Family: Linyphiidae

21. ***Linyphia** sp.

Host: *Hyalopterus pruni* (Geoffroy) from *Phragnites karka*, 28. iv. 1977, Churachandpur, Manipur.

Family: Salticidae

22. ***Rhene khandalaensis** Tikader

Host: *Macrosiphum rosae* (L.) from *Rosa* sp., 20.v.1977, Kalimpong, West Bengal.

Family: Theridiidae

23. ***Theridion** sp.

Host: *Cinara thujafilina* (del Guercio) from *Cupressus* sp. 14.v.1977, Gangtok, Sikkim; 20. v. 1977, Kalimpong, West Bengal.

Acknowledgements:- Tne authors are thankful to Indian Council of Agricultural Research, New Delhi and University Grants Commission, New Delhi for financing the research projects on aphids in Northeast India and Bhutan and to the Head of the Department of Zoology, University of Calcutta for laboratory facilities. Heartfelt thanks are also extended to Dr. P. Stary, Czechoslovak Academy of

Science, Prague, for kindly identifying the parasites and to the Zoological Survey of India, for comments on the predators of aphids.

REFERENCES

AZIS, S. A., S. N. HYDER, & M. H. ALI (1969) Studies on the host preference of *Coccinella septempunctata* L. *Indian. J. Ent.*, **31** (4) : 350–353.

NARAYANAN, E. S., B. R. SUBBA RAO & A. K. SHARMA (1958) Notes on three interesting parasitic Hymenoptera from India. *Indian J. Ent.*, **20** : 160–161.

NATH, D. K. & BIJITA SEN (1976) Some observations on aphidophagous Coccinellid beetles in mustard cultivation. *Sci. Cult.*, **42** (5) : 288–290.

RAMASESHIAH, G. & P. R. DHARMADHIKARI (1969) Aphelinid parasites of aphids in India. *C.I.B.C. Tech. Bull.*, **11** : 156–164.

RAO, V. P. (1969) Survey for natural enemies of aphids in India. *C.I.B.C. US PL* 480 *Project, Final Tech. Report*, 1–93.

SAXENA, H. P., P. SIRCAR & AMRIT PHOKELA (1970) Predation of *Coccinella septempunctata* L. and *Ischiodon scutellaris* F. on *A. craccivora. Indian J. Ent.*, **32**(1) : 105–106.

SHUJA-UDDIN (1973) Three species of *Trioxys* HALIDAY (Hymenoptera: Aphidiidae) recorded from India. *Indian J. Ent.*, **35**(1) : 9–14.

STARY, P. & A. K. GHOSH (1975) Aphid parasites (Hymenoptera: Aphidiidae) from Meghalaya, India. *Orient. Insects*, **9**(3) : 343–349.

STARY, P. & D. N. RAYCHAUDHURI (1977) A new species of *Pavesia* (Hymenoptera: Aphididae) parasitic on *Lachnus tropicalis* (Homoptera: Aphididae) in India. *Orint. Insects*, **11**(2) : 233–235.

VADIVELU, S., M. MOHANASUNDARAM & P. V.SUBBA RAO (1975) Record of parasites and predators on some south Indian crop pests. *Indian J. Ent.*, **37**(1) : 100–101.

Entomon, 1978, *Vol.* 3, *No.* 1, *pp.* 95 *to* 103

NEW AND LITTLE KNOWN APHIDS (HOMOPTERA : APHIDIDAE) FROM KUMAON HIMALAYA, INDIA

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(*Received 23 August 1977*)

Four new species, viz., *Greenidea (Trichosiphum) kumaoni, Jacksonia campanulata, Mollitrichosiphum (Metatrichosiphon) alnifoliae, Uroleucon fuscaudatus* and five other species are reported from the Kumaon Himalaya (Uttar Pradesh), India. Systematic position of the new species is discussed.

(*Key words :* **aphid, taxonomy, morphology, new species, India)**

Aphids occurring in the Kumaon Himalaya (Uttar Pradesh) are known through the works of Banerjee *et al.* (1969), Bhanotar and Ghosh (1969), Chakrabarti (1976a, b) Chakrabarti and Ghosh (1970), Chakrabarti *et al.* (1971a, 1972a, Chakrabarti and Raychaudhuri (1974, 1975), Chakrabarti and Verma (1975), David (1975), David *et al.* (1969, 1970, 1971), Ghosh, L.K. (1969, 1970), Quednau and Chakrabarti (1976) and Raychaudhuri and Banerjee (1975). As a result 121 species are so far known from this subhimalayan area.

In this paper, 9 more species are added to the previous list and thus the total number of species from the area stands at present 130. Out of these 9 species, 4 species, viz., *Greenidea (Trichosiphum) kumaoni, Jacksonia campanulata, Mollitrichosiphum (Metatrichosiphon) alnifoliae* and *Uroleucon fuscaudatus* are new to science.

1. Chromaphis hersutustibis Kumar and Lavigne

Specimen examined : Many alate viviparous females and nymphs, INDIA, UTTAR PRADESH, Bhowali, 24. v. 1969 : 5. iv. 1970 : 6. iv. 1970, Almora, 8. iv. 1970, Chaubattia 13. iv. 1970 from *Aleuroites moluccana*; 2 alate viviparous females, Kousani, 12. v. 1970 from *Alnus nepalensis* (vagrant); 8 alate viviparous females, Nainital, 23. v. 1969, Almora, 25. v. 1969, Kousani, 26. v. 1969 from Yellow Pan Water Trap; 2 apterous oviparous females, Bhowali, 24. v. 1969 from *Aleuroites molucanna* (Coll. S. Chakrabarti).

2. Greenidea (Trichosiphum) bucktonis Ghosh, Ghosh and Raychaudhuri

Specimen examined : 2 apterous viviparous females, INDIA, UTTAR PRADESH, Kanikhet, 12. iv. 1969 from an unidentified plant (Coll. S. Chakrabarti).

3. Greenidea (Trichosiphum) kumaoni, sp. nov.

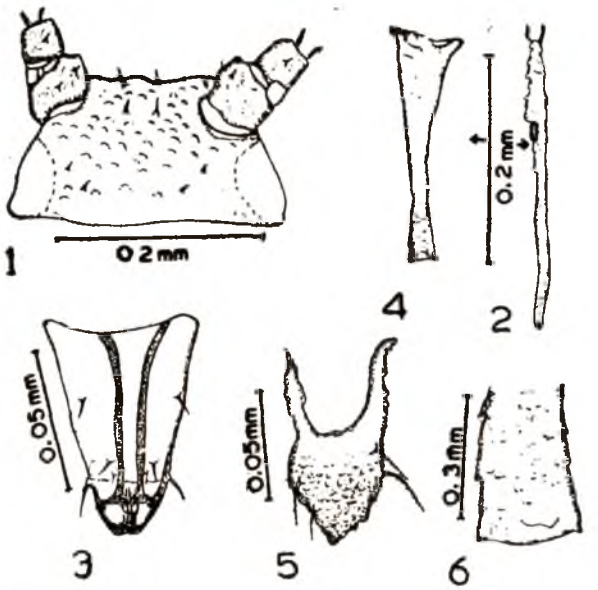
Apterous viviparous female : Body 1.92 mm long and 1.17 mm as maximum width. Head pale brown, smooth; dorsal hairs long with acute and furcated apices, longest hair

about 106 μ long and about 2.8 times the basal diameter of antennal segment III. Antennae about 0.83 the body; segments I and II brown, segments III, IV and basal half of segment V pale, rest concolorous with segment I; flagellum gradually more distinctly imbricated from basal half of segment III; processus terminalis about 2.4 times the base of segment VI and about 1.3 times the segment III; segment I with 8, II with 7 and III with 10 hairs; flagellar hairs long and short. with acuminate and blunt apices longest hair on segment III about 3.8 times the basal diameter of the segment and shortest hair about 0.6 the mentioned diameter. Rostrum long, reaches almost 3rd abdominal segment; ultimate rostral segment about 1.6 times the second joint of hindtarsus, segment 4 about 3.2 times the segment 5 and with about 10 secondary hairs. Dorsum of abdomen brown medially and marginally, rest pale smooth, but spinulose pleurally; dorsal hairs long and sparse, so that 10–12 hairs with acute, acuminate or furcated apices occur per segment on anterior tergites; longest hair on anterior tergites about 4.8 times the basal diameter of antennal segment III, 7th tergite with 2 hairs with acuminate to slightly furcated apices, longest hair about 3.6 times the basal diameter of antennal segment III; the 2 fine hairs on 8th tergite about 2.6 times the mentioned diameter; mid ventral area smooth. Siphunculi dark brown with the base and apex slightly paler, reticulated only at the base, about 0.22 the body and 0.9 the width of head including outer margins of eyes, about 3.8 times as long as its maximum width, at base about 2.75 times, at middle about 4.62 times and at apex about 1.87 times as thick as the middle diameter of hindtibiae; long and short siphuncular hairs mostly with acuminate apices and a few with furcated apices, longest of these being about 2.4 times the diameter of the siphunculi at base. Cauda semioval with a distinct median stylus which is about as long as its width at base, with about 8 hairs. Femora concolorous with head, tibiae concolorous with antennal segment III excepting the very base and apex which are slightly darker; femora faintly imbricated on inner margins; tibiae smooth excepting the very apices where a few spinulose striae present; tibial hairs long and short, longest being about 2.2 times as long as its middle diameter; first tarsal segments with 7 hairs.

Measurements of the holotype in mm : Length of body 1.92, width 1.17; antenna 1.6; antennal segments III : IV: V: VI 0.35: 0.21 : 0.22 : (0.20 + 0.48); ultimate rostral segment (0.159 + 0.05); second joint of hindtarsus 0.125 ; siphunculus 0.44.

Holotype : Apterous viviparous female, INDIA, UTTAR PRADESH, Nainital, 21.v. 1969, from? *Salvia leucantha* (Coll. S. Chakrabarti) (type material deposited in the Entomology Laboratory, Department of Zoology, University of Calcutta).

Remarks : The species in having smooth hindtibiae comes close to *Greenidea* (*Trichosiphum*) *carpini* Takahashi (1963), *G.* (*T.*) *kuwanai* (Pergande, 1906), *G.* (*T.*) *nipponicum* Suenaga (1934) and *G.* (*T.*) *sikkimensis* Raychaudhuri *et al.* (1973), but differs from *carpini*, *kuwanai* and *sikkimensis* in having smooth midventral area and form *nipponicum* in having different types of apices of the body hairs. However, it has to be admitted that besides smoothness in the midventral area, the species comes close to *carpini*, but the number of hairs in first 3 antennal segments make the species a distinct one. So far no members of Greenideinae has been recorded from *Salvia* spp. One of the authors (S. C) recently has examined a collection of this new species infesting *Quercus* sp. at Garhwal Himalaya.



Figs. 1–6. *Jacksonia campanulata*, sp. nov., apterous viviparous female : 1. Head (dorsum); 2. Antennal segment VI; 3. Ultimate rostral segment; 4. Siphunculus; 5. Apical portion of siphunculus; 6. Cauda.

4. Jacksonia campanulata, sp. nov.
(Figs. 1–6)

Apterous viviparous female : Body 1.0–1.07 mm long with 0.6 mm as maximum width. Head (Fig. 1) brown to dark brown anteriorly, somewhat scabrous dorsally, ventrally spinulose at least anteriorly, with weakly developed lateral frontal tubercles bearing 2 short hairs ventrally. Antennae about 0.83–0.87 the body; segment I brown dorsally, smooth, with 2 long and 2 short hairs; segment II paler, smooth with hairs as on segment I; flagellum pale and distinctly imbricated; processus terminalis (Fig. 2) about 2.0–2.2 times as long as the base of segment VI and nearly to as long as segment III; hairs on flagellum sparse, short and blunt, longest hair on segment III about 0.2 times the basal diameter of the segment. Rostrum reaches nearly hindcoxae; ultimate rostral segment (Fig. 3) rather blunt, about as long as second joint of hindtarsus and with 2 secondary hairs; longitudinal spinulose striae specially present on segment 3 of the rostrum. Thorax pale, dorsum corrugated. Abdominal dorsum pale, corrugated, with very short and blunt hairs at least on anterior tergites; 7th tergite with 4 short, blunt hairs and 8th tergite with 2 slightly longer but blunt hairs; longest hair on anterior tergites about 0.3–0.4 the basal diameter of antennal segment III; abdominal venter with spinulose striae. Siphunculi (Fig. 4) pale on about basal 0.66 portion, rest pale brown, broadest at base and narrowest at middle, nearly smooth on basal 0.33 portion, rest gradually more distinctly imbricated apicad and with scattered spinules on surfaces, without an apical flange (Fig. 6), about 0.23 as long as cauda. Cauda (Fig. 5) elongate, slightly constricted at the base and swollen at middle, with 4 hairs. Legs pale excepting the very apices of femora, knees, very apices of tibiae and tarsi which are slightly dusky; femora nearly smooth and with spinules on basal

0.06 portion; tibiae smooth first tarsal segment with 3 hairs and second tarsal segment with 2 dorsal and 1 ventral hairs.

Measurements of the holotype in mm: Length of body 1.0, width 0.06; antenna 0.87; antennal segments III : IV : V : VI 0.19 : 0.13 : 0.12 : (0.10 + 0.22); ultimate rostral segment 0.07; second joint of hindtarsus 0.07; siphunculus 0.23; cauda 0.07.

Holotype : Apterous viviparous female INDIA, UTTAR PRADESH, Almora, 9. iv. 1970 from *Campanula colorata* (Coll. S. Chakrabarti). **Paratypes** : 1 apterous viviparous female and nymphs, collection data as in the holotype. (Holotype deposited in the Entomology Laboratory, Department of Zoology, University of Calcutta).

Remarks: The species can be differentiated from *Jacksonia conandri* (Takahashi, 1961) by the ratio of ultimate rostral segment to second joint of hindtarsus, absence of dorsal sclerotisation and by the number of hairs on the lateral frontal tubercles and cauda, from *japonica* Takahashi (1961) by the ratio of processus terminalis to base of antennal segment VI and by the number of caudal hairs and from *papillata* Theobald (1923) by much longer processus terminalis to base of antennal segment VI and by much longer siphunculi in comparison to cauda.

5. Mollitrichosiphum (Metatrichosiphon) alnifoliae, sp. nov.

Apterous viviparous female: Body 2.04–2.44 mm long and 0.79 – 0.85 mm as maximum width. Head pale, smooth, dorsal cephalic hairs long, with fine to flagellate apices, longest hairs on vertex about 131–170 μ long and about 0.40–0.45 the basal diameter of antennal segment III; venter of head smooth. Antennae about 0.50–0.64 the body; processus terminalis about 1.27–1.34 times the base of segment VI and 0.43–0·57 the segment III; basal 0.6 portion of segment VI smooth, rest of the flagellum gradually more distinctly imbricated from base to apex; hairs on flagellum long and short, with acuminate apices, shortest hair on segment III about 42–75 μ long and longest hair about 158–188 μ long and about 1.2–2.1 and 4.2–5.7 times the basal diameter of the segment, respectively. Rostrum reaches 3rd abdominal segment; rostral segments 4 and 5 slender distinct, acute, with dark apex, about 1.68–2.0 times the second joint of hindtarsi; segment 4 about 4.7-6.8 times segment 5 and with 8 accessory hairs. Abdominal dorsum pale, smooth; hairs on dorsum long, with acuminate apices, anterior tergites with 16–20 hairs (including marginals) per segment, 7th tergite with 4 hairs and 8th tergite with 2 hairs; longest hair on anterior tergites about 116–170 μ long and 3.1–5.2 times basal diameter of antennal segment III, similar hairs on 7th and 8th tergites about 2.8–3.1 times mentioned diameter; venter of abdomen densely spinulose on the margins and less so on medially. Siphunculi nearly straight, slender, sparsely spinulose, pale brown except apical 0.12 portion which is brown to dark brown, about 0.52–0.65 the body, about 12.1–13.2 times as long as its maximum width and 2.7–3.53 times the width of head across the outer margin of the eyes, at base about 2.4-2.8 times, at middle about 2.27–2.90 times and at apex about 1.35–1.70 times as thick as the middle diameter of hindtibia; siphuncular hairs many, with flagellate apices, longest hair about as long as to slightly longer than the basal diameter of the siphunculi. Cauda semioval with 4 hairs. Legs pale brown, femora and tibiae nearly smooth; hairs on femora and tibiae with flagellate apices, hindtibiae with 30–44 transverse ridges on the entire surface of the tibiae except basal 0.1 and apical 0.2 portion; first tarsal segments with 7, 7, 7, hairs.

Measurements of the holotype in mm : Length of body 2.20, width 0.82; antenna 1.30 ; antennal segments III : IV : V : VI 0.42 : 0.17 : 0.19 : (0.16 + 0.21); ultimate rostral segment (0.18 + 0.03); second joint of hindtarsus 0.11; siphunculus 1.30.

Alate viviparous female : Body 2.02-2.19 mm long and 0.69–0.79 mm as maximum width. Head brown, smooth longest hair on the vertex about 130–140 μ long and 3.5–3.7 times the basal diameter of antennal segment III. Antennae brown to dark brown, about 0.70–0.73 times the body; processus terminalis about 0.44–0.47 the segment III and 1.25–1.52 times the base of segment VI; segment III with 11–18 round secondary rhinaria distributed over the segment except basal 0.06 and apical 0.2 portion of the segment; longest hair on segment III about 2.0–2.8 times the basal diameter of the segment. Ultimate rostral segment about 1.63–1.80 times the second joint of hindtarsus; segment 4 about 6–7 times the segment 5. Midthoracic lobe distinct and dark brown. Abdominal dorsum smooth, pale or with a 'U'–shaped pale brown patch on the middle of abdomen; longest hair on anterior tergites about 2.5-3.0 times the basal diameter of antennal segment III, on 7th and 8th tergites about 2.2–2.8 times the mentioned diameter; venter of abdomen evenly spinulose. Siphunculi long, cylindrical, pale at very base, rest brown to dark brown, sparsely spinulose except the very apex which is densely so, about 16.82–18.33 times as long as its maximum width and 3.47–4.0 times the width of head across the eyes, at base about 2.3–2.6 times, at middle about 2.0–2.5 times and at apex about 1.55–1.65 times as thick as the middle diameter of hindtibiae; longest hair on siphunculi about 10–11 times the basal diameter of the antennal segment III. Cauda with 4 hairs. Femora pale brown, tibiae with 43–55 transeverse ridges, wing venation normal, veins conspicuous, radial sector curved. Other characters as in the apterous viviparous females.

Measurements of one specimen in mm : Length of body 2.19, width 0.69; antenna 1.54; antennal segments III : IV : V : VI 0.54 : 0.19 : 0.23 : (0.19 + 0.24); ultimate rostral segment (0.17 + 0.03); second joint of hindtarsus 0.11; siphunculus 1.63.

Holotype: Apterous viviparous female, INDIA, UTTAR PRADESH, Kousani, 27. v. 1969 from *Alnus nepalensis* (Coll. S. Chakrabarti). **Paratypes** : Many apterous viviparous females, 6 alate viviparous females and nymphs, collection data as in the holotype (deposted in the Entomology Laboratory, Department of Zoology, University of Kalyani except 1 apterous and 1 alate viviparous females (paratypes) which are in the Entomology laboratory, Department of Zoology, University of Calcutta).

Remarks : Following Ghosh (1974) the present new species in having fine dorsal hairs with acute apices and 2–4 hairs on the 7th tergite comes close to *Mollitrichosiphum (Metatrichosiphon) niitakaensis* (Takahashi, 1937) and *M. (M.) alni* Ghosh, Ghosh and Raychaudhuri (1970). From *M. (M.) nittakaensis*, the new species differs in having 30–55 stridulatory ridges on the hind tibiae (in *niitakaensis* about 80); siphunculi in apterae and in alatae 12.1–13.2 times and 16.82–18.33 times as long as their maximum width respectively (in *alni*, 20–25 times and 23–30 times, respectively) and 2.7–3.53 and 3.47–4.0 times the width of head across the outer margin of the eyes respectively, (in *alni* always more than 4 times), 7th tergite with 4 hairs (in *alni* 2 hairs) besides comparatively shorter hairs on the dorsum of abdomen.

6. Myzus unifoliae (Shinji)

Specimen examined: Many apterous viviparous females, INDIA, UTTAR PRADESH, Nainital, 7. iv. 1970, Almora, 9.iv. 1970, Dauladevi (Almora), 10. iv. 1970 from *Rubia cordifolia* (Coll. S. Chakrabarti).

7. Nasonovia (Kakamia) rostrata David and Hameed

Specimen examined : 23 apterous viviparous females, 4 alate viviparous females, INDIA, UTTAR PRADESH, Almora. Oucham, 13.x. 1970, 1 apterous viviparous female, 3 alate viviparous females, Almora, Jatoli, 22.x.1970 from *Strobilanthes penstemonoides;* 2 apterous viviparous females and 2 alate viviparous females, Almora, Jatoli. 22.x. 1970 from *Adenocaulon bicolor* (Coll. S. Chakrabarti).

Remarks : David and Hameed (1974) described *Nasonovia (Kakamia) rostrata* from 5 apterous and 4 alate viviparous females infesting *Clerodendron infortunatum.* Although there exist some differences between the present material and that of David and Hameed (1974) but these materials cannot clearly be separated and hence some of the characters of *rostrata* have been extended to accommodate this present material. These are as follows :

Apterous viviparous females : Body 1.58–2.31 mm long; antennae about 1.2–1.5 times as long as body; processus terminalis about 5.7–7.9 times as long as base of segment VI; longest hair on antennal segment III about 0.95–1.33 times as long as basal diameter of the segment; ultimate rostral segment 1.85–2.3 times as long as the second joint of hindtarsus; siphunculi 0.16-0.18 times the body and 1.33–2.0 times the cauda.

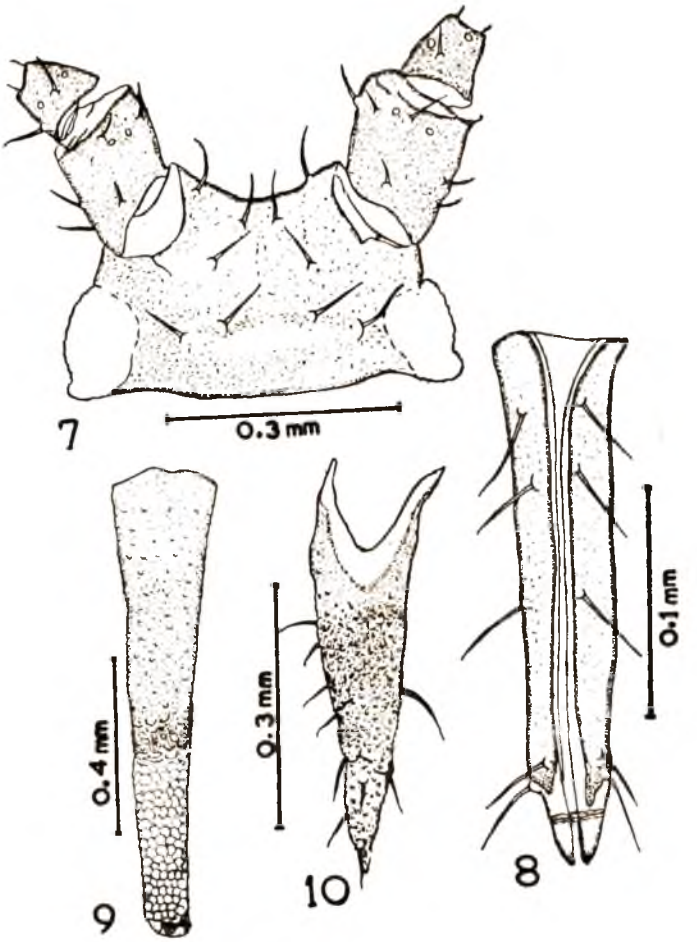
8. Pemphigus mordvilkoi Cholodkovsky

Specimen examined : 5 apterous viviparous females and many alate viviparous females, INDIA, UTTAR PRADESH. Chaubattia, 29.v. 1969 from *Populus ciliata* (Coll. S. Chakrabarti).

Remarks : These specimens were found to produce stem galls of the host plants and were reported as *Pemphigus immunis* Buckton by Chakrabarti *et al.* (1970a).

9. Uroleucon fuscaudatus sp. nov. (Figs. 7–10)

Apterous viviparous female: Body 2.04–2.64 mm long with 0.82–1.27 mm as maximum width. Head (Fig. 7) brown to dark brown, with well developed diverging lateral frontal tubercles, finely granulose both dosally and ventrally and with a pair of minute dorsal tubercles; dorsum of head with 10 hairs (including those of the lateral frontal tubercles), with acute apices; lateral frontal tubercles in distinctly scabrous just at the base of antennae and with one dorsal and one ventral hair; longest hair on vertex about 55-68μ long and about 1.5–2.0 times the basal diameter of antennal segment III. Antennae about 1.1–1.4 times body; antennal segments I and II coloured like the head, flagellum pale with the area of segment III bearing secondary rhinaria and the apices of segments III, IV and V dusky, segment III smooth, rest of the flagellum gradually imbricated apicad; processus terminalis about 4.8–5.3 times the base of segment VI; segment III excepting basal 0.14 and apical 0.35 portion with 12–24 tuberculate secondary rhinaria distributed mostly in a row on its outer margin; hairs on the flagellum with slightly acuminate apices, longest hair on segment III about 26–30μ long and about 0.75–1.1 times the basal diameter of the segment. Rostrum brown to dark brown, reaches beyond hindcoxae; ultimate rostral segment (Fig. 8) long, about 1.5–1.7 times the second joint of hindtarsi and with 4 pairs of accessory hairs. Midthoracic furca with a short base. Abdomen pale,



Figs. 7–10. *Uroleucon fuscaudatus*, sp. nov., apterous female : 7. Head (Dorsal); 8. Ultimate rostral segment; 9. Siphunculus; 10. Cauda.

post-siphuncular sclerite well developed, ante-siphuncular sclerite ill-developed; dorsal hairs on dark sclerotic bases thick and with apices similar to those on flagellum, 7th and 8th tergites, each with 4 hairs, longest hair on anterior tergites about 60–64 μ long and about 1.6–2.1 times the basal diameter of antennal segment III; similar hairs on 7th and 8th tergites of about the same length with those on anterior tergites. Siphunculi (Fig. 9) long gradually narrowing towards apex, with basal 0.5 portion dark brown, rest brown to pale brown, imbricated, reticulated on apical 0.33 portion, about 0.3–0.36 the body and 1.65–2.0 times the cauda. Cauda (Fig. 10) sclerotic, blackish on nearly basal 0.5 portion, rest pale, elongate and gradually narrowing towards the apex, with 14–20 hairs. Legs with coxae, apical 0.5 portion of femora, knees, apical 0.25 portion of tibiae and whole of tarsi brown to dark brown, rest pale to pale brown. First tarsal chaetotaxy variable; first tarsal segment of fore- and hindlegs with 4–5 hairs but that of midlegs with 3 hairs.

Measurements of the holotype in mm: Length of body 2.44, width 1.0; antenna 2.71; antennal segments III : IV : V : VI 0.76 : 0.52 : 0.49 : (0.16 + 0.76); ultimate rostral segment 0.23; second joint of hind-tarsus 0.14; siphunculus 0.81; cauda 0.45.

Holotype: Apterous viviparous female, INDIA, UTTAR PRADESH, Almora, Kapcote, 26. x. 1970 from *Inula rubricaulis* (Coll. S. Chakrabarti).

Paratypes: 4 apterous viviparous females and nymphs, collection data as in the holotype; 3 apterous viviparous females and nymphs, INDIA, UTTAR PRADESH, Almora, Loharkhet, 10.x. 1970 from *Inula rubricaulis* (Coll. S. Chakrabarti) (deposited in the Department of Zoology, University of Kalyani except 2 paratypes of which one in the Entomology Laboratory, Department of Zoology, University of Calcutta and the other in the collection of Dr. D. Hille Ris Lambers, The Netherlands).

Remarks: This new species is a member of *Uroleucon* (*Uromelon*) in respect of the nature of cauda and comes close to *Uroleucon inulicola* complex (Hille Ris Lambers, 1939), but can be distinguished from the latter in having longer last rostral segment, more slender cauda, much more extensive reticulation on siphunculi, 3–5 hairs on first tarsal segments in the same specimen and pale to pale brown basal portion of tibiae besides other characters. The name *Uroleucon* is being used here in preference to *Dactynotus* Refinesque till emendation from International Commission on Zoological Nomenclature is finally forthcoming in this regard.

Acknowledgements:– The authors express thanks to Dr. D. Hille Ris Lambers, Bennekom, The Netherlands for the comments on the identity of *Pemphigus mordvilkoi* Cholodkovsky and *Uroleucon fuscaudatus* sp. nov. One of the authors (SC) is thankful to the Heads, Department of Zoology, University of Kalyani and University of Calcutta for laboratory facilities.

REFERENCES

BANERJEE, H., A. K. GHOSH & D. N. RAYCHAUDHURI (1969) On a collection of Aphids (Homoptera) from Kuti Valley, West Himalaya. *Orient. Insects*, **3**(3) : 255–264.

BHANHOTAR, R. K. & L. K. GHOSH (1969) *Micromyzus judenkoi* CARVER (Homoptera: Aphididae), a new record from India. *Sci. Cult.*, **35** : 72.

CHAKRABARTI, S. (1976a) Two new species of aphids (Homoptera: Aphididae) from north western Himalaya, India. *J. Linn. Soc. Zool.*, **58**(3) : 263–271.

CHAKRABARTI, S. (1976b) A new synonym and hitherto unknown morphs of *Chaetosiphon* (MORDWILKO) (Insecta: Homoptera) described from India. *Sci. Cult.*, **42**(6) : 335–336.

CHAKRABARTI, S. & A. K. GHOSH (1970) On the rose infesting aphids (Homoptera: Aphididae) in India. *Indian J. Hort.*, **27** (3–4) : 226–232.

CHAKRABARTI, S., A. K. GHOSH & D. N. RAYCHAUDHURI (1971a) New records of aphids (Homoptera : Aphididae) from Uttar Pradesh, India. *Sci. Cult.*, **37**(5) : 247–248.

CHAKRABARTI, S., A. K. GHOSH & D. N. RAYCHAUDHURI (1971b) Three new species of aphids (Homoptera: Aphididae) from north west Himalaya, India. *Kontyu*, **39**(4) : 368–372.

CHAKRABARTI, S., A. K. GHOSH & D. N. RAYCHAUDHURI (1972a) On some undescribed morphs and new records of aphids (Homoptera: Insecta) from Kumaon Himalaya. *Curr. Sci.*, **41**(2): 70–71.

CHAKRABARTI, S., A. K. GHOSH & D. N. RAYCHAUDHURI (1972b) A new genus, a new species and further records of aphids (Homoptera : Aphididae) from Kumaon Hills North West Himalaya, India. *Orient. Insects*, **6**(3) : 387–400.

CHAKRABARTI, S. & D. N. RAYCHAUDHURI (1974) A new subspecies and some synonymies of aphids species (Homoptera: Aphididae) from India. *Orient. Insects*, **8**(2) : 303–305.

CHAKRABARTI, S. & D. N. RAYCHAUDHURI (1975) Aphids (Homoptera: Aphididae) of Sundhardunga valley in Kumaon Himalaya (Uttar Pradesh), India. *Orient. Insects*, **9** (2) : 195–211.

CHAKRABARTI, S. & K. D. VERMA (1975) A new species of aphid (Homoptera: Aphididae) from north western Himalaya. *Orient. Insects*, **9**(2): 167–171.

DAVID, S. K. (1975) A taxonomic review of *Macrosiphum* (Homoptera: Aphididae) in India. *Orient. Insects*, **9**(4) : 461–493.

DAVID, S. K. & S. F. HAMEED (1974) Second species of *Nasonovia-Kakamia* Complex (Homoptera: Aphididae) from north Western India. *Orient. Insects*, **8**(4) : 503–504.

DAVID, S. K., K. NARAYANAN & S. G. RAJASINGH (1969) New records of aphids (Homoptera: Aphididae) in India. *Bull. Ent.*, **10**(2) : 158–159.

DAVID, S. K., K. NARAYANAN & S. G. RAJASINGH (1970) Five new species of aphids (Homoptera) from north western India. *Orient. Insects*, **4**(4) : 413–426.

DAVID, S. K., K. NARAYANAN & S. G. RAJASINGH (1971) Records of aphids in new regions in India. *Madras agric. J.*, **58**(5) : 392–394.

GHOSH, A. K. (1974) New species and new records of aphids (Homoptera: Aphididae) from north east India. *Orient. Insects*, **8**(2) : 161–175.

GHOSH, A. K., M. R. GHOSH & D. N. RAYCHAUDHURI (1970) Studies on the aphids (Homoptera: Aphididae) from eastern India. *Orient. Insects*, **4**(2) : 193–203.

GHOSH, L. K. (1969) On a collection of aphids (Homoptera: Aphididae) from Utter Pradesh, India. *Sci. Cult.*, **35** : 493.

GHOSH, L. K. (1970) A new species of *Uroleucon* MORDWILKO from India (Homoptera : Aphididae). *Insecta matsum.*, **8** (Suppl.) : 1–4.

PERGANDE, T. (1906) Descriptions of two new genera and three new species of Aphididae. *Ent. News*, **17** : 205–210.

QUEDNAU, F. W. & S. CHAKRABARTI, (1976) A new genus and three new species fo aphids (Homoptera : Aphididae) from northwest India. *Can. Ent.*, **108** : 461–468.

RAYCHAUDHURI, D. N. & C. BANERJEE (1974) A study on the genus *Melanaphis* (Homoptera: Aphididae) with description of new taxa from India. *Orient. Insects*, **8**(3) : 365–389.

RAYCHAUDHURI, D. N., M. R. GHOSH, M. BANERJEE, & A. K. GHOSH (1973) Studies on the aphids (Homoptera: Aphididae) from eastern India. *Kontyu*, **41**(1) : 53–73.

SUENAGA, H. (1943) Die Grenideiden-blattlause Japans (Hemipt., Aphididae). *Bull. Kagoshima imp. Coll. Agric For.*, **1** : 789–804.

HILLE RIS LAMBERS, D. (1939) Contribution to a monograph of the Aphididae of Europe. II. *Temminckia*, **4** : 1–134.

TAKAHASHI, R. (1937) Addition to the aphid fauna of Formosa (Hemiptera). IV. *Philiipp. J. Sci.*, **63** : 1–19.

TAKAHASHI, R. (1961) Three new genera of subfamily Aphididae from Japan (Aphididae: Homoptera). *Bull. Univ. Osaka Prefect.*, **11**(B) : 1–10.

TAKAHASHI, R. (1963) Two new genera and five new or little known species of Aphididae from Japan (Homoptera). *Kontyu*, **31**(3) : 159–168.

THLOBALD, F. V. (1923) A new genus and two new species of aphids from Ross-shire. *Scott. Nat.*, 19–20.

Entomon, 1978, *Vol.* 3, *No.* 1, *pp.* 105 *to* 110

HITHERTO UNKNOWN SEXUALES OF TWO APHID SPECIES FROM SIKKIM, NORTHEAST INDIA

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(*Received 24 March 1978*)

Alate males and apterous females of *Brachymyzus jasmini* Basu and *Micromyzus kalimpongensis* Basu are described for the first time from Sikkim, northeast India.

(*Key words :* **alate male, apterous oviparous female)**

While working on a collection of aphids made during the period 1974–75 hitherto unknown alate males and apterous oviparous females of *Brachymyzus jasmini* Basu and *Micromyzus kalimpongensis* Basu could be found. These are described in the present paper.

Materials of these morphs are in the collection of the Entomology Laboratory, Department of Zoology, University of Calcutta.

1. Brachymyzus jasmini Basu

Alate male (Fig. 1) : Body 1.83 mm long with 0.70 mm as its maximum width. Head brown, without any frontal tubercles; with a few spinules at the base of antennal sockets; dorsal cephalic hairs acute, about 0.02 mm long. Antennae 6-segmented, concolorous with head, about 0.95 × the length of the body; segments I and II with a few spinules; flagellum gradually distinctly imbricated apicad; segments III, IV and V with many protuberant secondary rhinaria arranged irregularly along their entire lengths; processus terminalis about 3.11 × the base of segment VI; flagellar hairs acute, longest one on segment III about 1.14 × its basal diameter. Rostrum short and pale; ultimate rostral segment as long as second joint of hindtarsus and without secondary hair. Mid-abdominal dorsum with a distinct brownish pigmented sclerotic patch on tergites 3–5, tergites 6th, 7th and 8th each with a transverse sclerotic band; marginal sclerites present on segments 1–5; dorsal abdominal hairs with acute apices, longest hair on anterior tergites about 2.71 × the basal diameter of antennal segment III; tergite 8 with 2 long acute hairs and these about 2.57 × the said diameter. Siphunculi cylindrical, pale brown, slightly scabrous, with an apical flange, about 0.06 × the length of the body and about 1.80 × pale brown subpentagonal cauda bearing 4 curved hairs. Legs pale brown: femora and tibiae smooth; first tarsal chaetotaxy 3, 3, 3. Wing venation normal; veins faintly bordered brown. Genitalia well developed.

Measurements of the alate male in mm : Length of body 1.83, width 0.70; antenna 1.75, segments III:IV:V:VI 0.58:0.30: 0.22: (0.12 + 0.38); ultimate rostral segment 0.08; second segment of hindtarsus 0.07; siphunculus 0.12; cauda 0.06.

Apterous oviparous female (Fig. 2) : Body pale, about 0.97–1.01 mm long with 0.44–0.45 mm as its maximum width. Head with low lateral prominences and a wide frontal furrow. Antennae 6-segmented, about 0.65 × the length of the body;

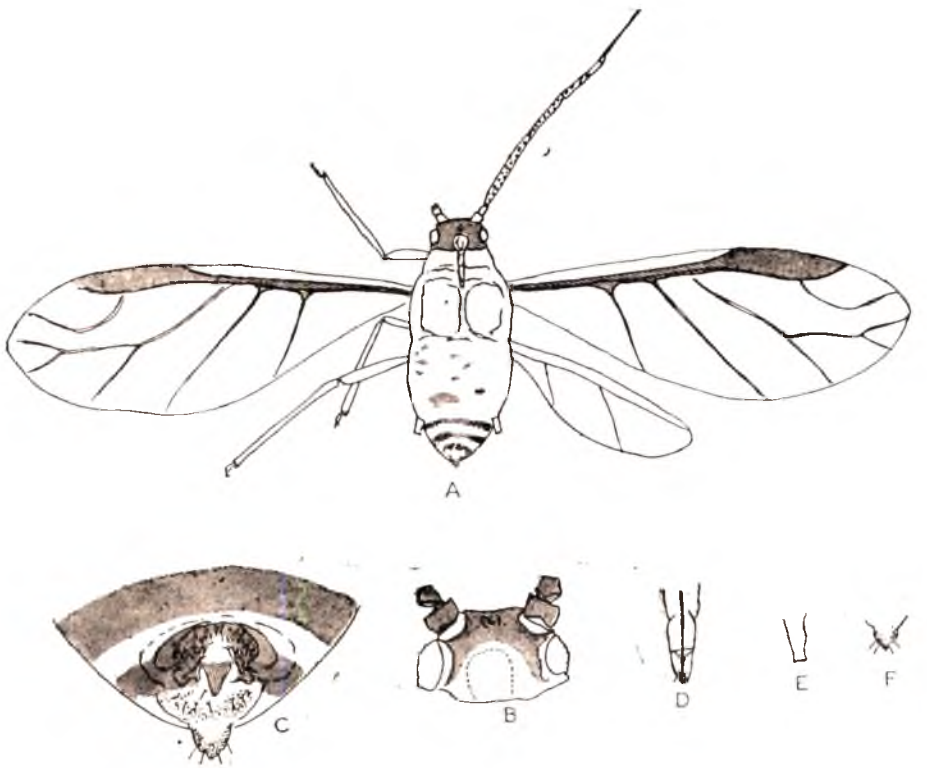

Fig. 1. *Brachymyzus jasmini* Basu : Alate male. A. entire body; B. antenna; C. posterior portion of abdomen; D. ultimate rostral segment; E. siphunculus; F. cauda.

segments I and II pale; flagellar segments pale brown; longest hair on antennal segment III about 0.31–0.42 × its basal diameter; processus terminalis either broken or deformed. Rostrum pale, just reaching hindcoxae; ultimate rostral segment about 0.84–1.0 × second segment of hindtarsus and without secondary hair. Abdominal dorsum pale and smooth; longest hair on anterior tergites about 2.12–2.28 × the basal diameter of antennal segment III; tergites 7 and 8 with 4 and 2 hairs respectively. Siphunculi pale, almost cylindrical with ill-developed flange, about 0.06–0.07 × the length of the body and about 1.25–1.66 × pale pentagonal cauda bearing 4–6 long hairs. Legs pale, almost smooth, hindtibiae swollen, with about 25 pseudosensoria; first tarsal chaetotaxy 3, 3, 3.

Measurements of one apterous oviparous female in mm: Length of body 1.01, width 0.44; antenna 0.63, segments III : IV : V : VI 0.16 : 0.09 : 0.10 : (0.06 + 0.10); ultimate rostral segment 0.06; second segment of hindtarsus 0.06; siphunculus 0.06; cauda 0.05.

Specimens examined: INDIA : SIKKIM : Tsungthang at 1666 m, 2 apterous oviparous ♀♀ and 3 nymphs; 14. xi. 1974, from *Nellia* sp. (Rosaceae), coll. P. K. Mondal; 1 alate ♂ from same locality and date, from *Pilea microphylla* (Urticaceae) coll. P. K. Mondal.

Remark : Basu, A. N. (1964) described this species from apterous and alate viviparae collected in Darjeeling district of West Bengal on *Jasminum humile* (Oleaceae).

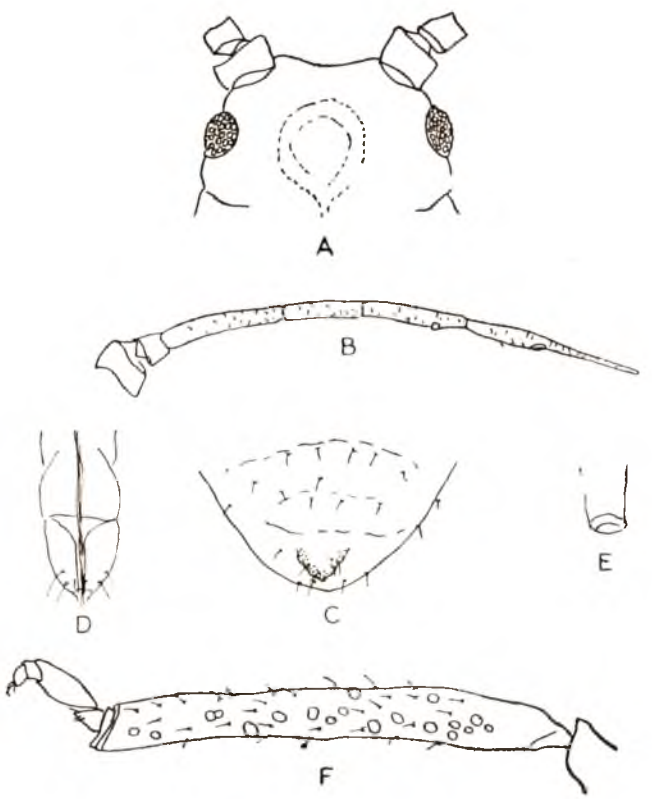

Fig. 2. *Brachymyzus jasmini* Basu : Apterous oviparous female. A. dorsum of head; B. antenna; C. posterior portion abdomen; D. ultimate rostral segment; E. siphunculus; F. hindtibia.

In Sikkim viviparae and apterous oviparae have been found on *Nellia sp.* (Rosaceae). Thus it appears that this species exhibits polyphagism. Unlike these morphs the single alate male was collected from *Pilea microphylla* (Urticaceae) which seems to be a doubtful host for this aphid.

However, find of sexuals of this species along with viviparae hints at the possibility of completion of holocyclic life cycle in the area.

2. Micromyzus kalimpongensis Basu

Alate male : (Fig. 3) Body about 1.38–1.60 mm long and about 0.62–0.79 mm wide. Head brownish, sparsely spinulose on both surfaces; with low lateral frontal prominences; dorsal cephalic hairs long with acuminate apices. Antennae 6-segmented, about 0.79–0.95 × the length of the body; segments I and II concolorous with head, scabrous and with few spinules; flagellum pale brown, gradually more distinctly imbricated apicad; processus terminalis 3.80–4.19 × the base of segment VI; segment III with 24–38, IV with 18–25 and V with 7–11 protuberant secondary rhinaria arranged irregularly along the entire lengths; primary rhinaria protuberant, ciliated, hairs on segment III sparse, about 0.44–0.83 × its basal diameter and with blunt apices. Rostrum extending up to hindcoxae; ultimate rostral segment

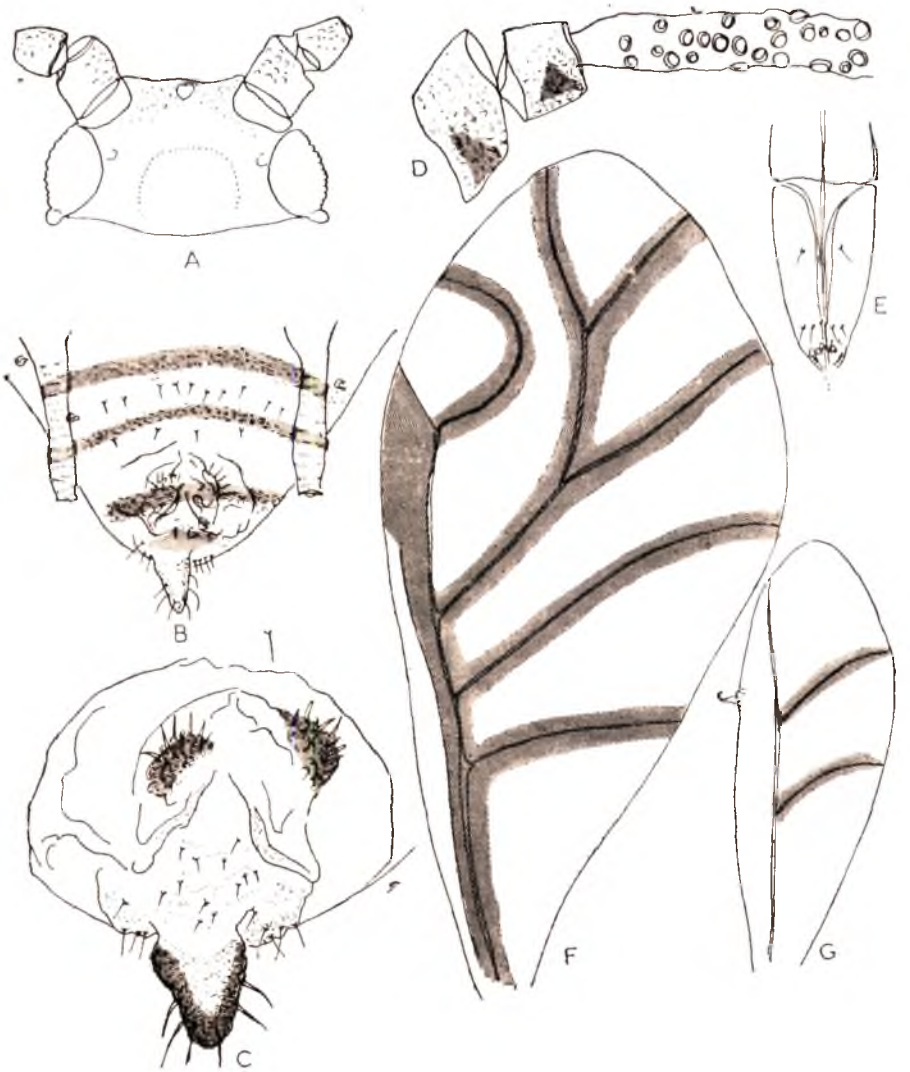

Fig. 3. *Micromyzus kalimpongensis* Basu : Alate male. A. dorsum of head; B. posterior portion of abdomen; C. genitalia; D. portion of antenna; E. ultimate rostral segment; F. forewing; G. hindwing.

1.23–1.37 × second segment of hindtarsus and bears 2 secondary hairs. Abdomen pale, pre-siphuncular tergites with marginal sclerites, dorsal hairs short, blunt, longest hair on anterior tergites about 0.70–1.10 × the basal diameter of antennal segment III and those on tergites 7 and 8 about 0.75–1.01, 0.77–1.02 × the above mentioned diameter respectively. Siphunculi cylindrical, pale brown, imbricated, distinctly on basal half and less or so on distal half, with a distinct distal constriction followed by a well developed flange; about 0.15–0.19 × the length of the body. Cauda about 2.50–3.01 × the length of siphunculi, constricted at the base, blunt apex and bears 5–6 hairs. Male genitalia distinct. Legs brown, with distal portion of femora dark; femora

spinulose on both surfaces; tibiae smooth; first tarsal chaetotaxy 3, 3, 2. Wing veins bordered brown.

Measurement of one alate male in mm : Length of body 1.47, width 0.79; antenna 1.38, segments III: IV: V: VI 0.34:0.23: 0.18: (0.09 + 0.38); ultimate rostral segment 0.10; second segment of hind-tarsus 0.07; siphunculus 0.23; cauda 0.08.

Apterous oviparous female (Fig. 4): Body about 1.35 mm long and about 0.87 mm as its maximum width. Head brown, densely spinulose on both surfaces; lateral frontal tubercles low but distinct with inner margin diverging; frons slightly convex; dorsal cephalic hairs with blunt to slightly swollen apices. Antennae 6-segmented, brown, with the apex of segment V and base of segment VI dark brown; about 0.87 × the length of the body; segments I and II scabrous; the flagellum densely imbricated: secondary rhinaria absent; processus terminalis about 3.14 × base of segment VI; longest hair on segment III about 0.33 × its basal diameter. Rostrum extending little beyond hindcoxae; ultimate rostral segment about 1.26 × segment of hindtarsus and bears 2 secondary hairs. Midthoracic furca sessile. Abdominal tergum pale to pale brown, pre-siphuncular tergites with polygonal network of wrinkles, post-siphuncular segments with transverse rows of spinules both on tergites and sternites,

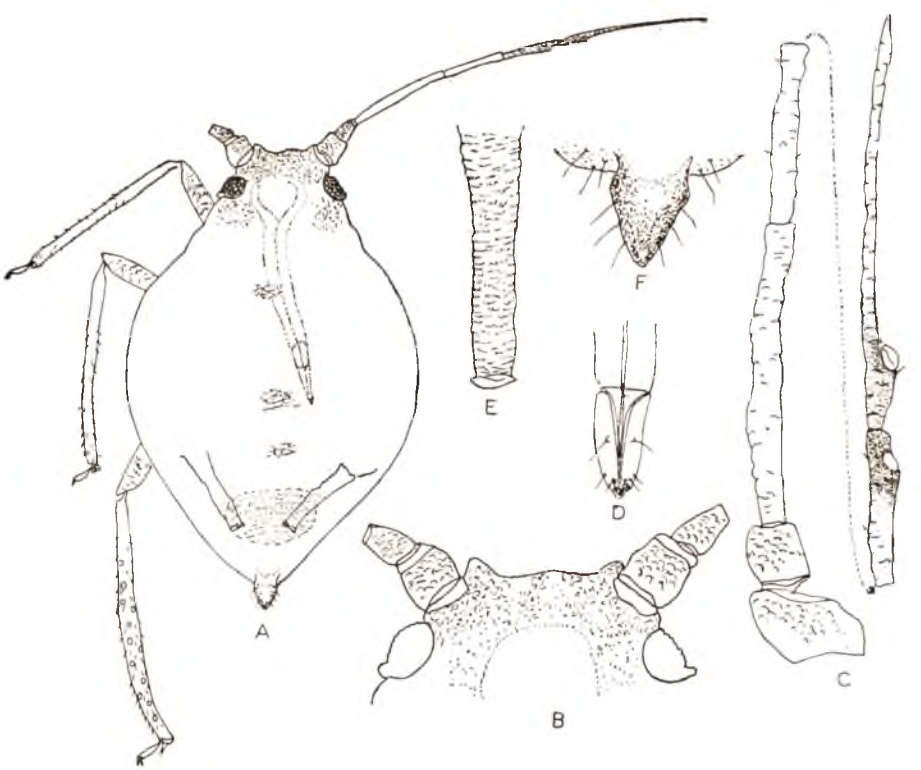

Fig. 4. *Micromyzus kalimpongensis* Basu : Apterous oviparous female. A. entire body; B. dorsum of head; C. antenna; D. ultimate rostral segment; E. siphunculus; F. cauda.

dorsal hairs short, blunt and about as long as the basal diameter of the antennal segment III. Siphunculi brown, darker at apices, imbricated throughout, broadest at base then narrowing gradually expanding again before the constriction near the well developed flange; about 2.37 × the length of the body. Cauda darker than siphunculi, with a bulbous base and blunt apex, bearing 5 hairs. Femora brown, ventrally scabrous but dorsally with transverse spinules; tibiae of hindlegs swollen, with 20–25 pseudosensoria; first tarsal chaetotaxy 3, 3, 2.

Measurement of one apterous oviparous female in mm: Length of body 1.36, width 0.87, antenna 1.19, segments III: IV: V: VI 0.33 : 0.19 : 0.12 : (0.09 + 0.30); ultimate rostral segment 0.10; second segment of hindtarsus 0.08; siphunculus 0.26; cauda 0.10.

Specimens examined: INDIA : SIKKIM : Ringon at 1600 m, 1 apterous oviparous ♀, 17 alate ♂♂ and 15 nymphs, 9. xi. 1974, from *Elettaria cardamomum* (Zingiberaceae), coll. P. K. Mondal; 1 apterous oviparous ♀, 11 alate ♂♂ and 19 nymphs, Sikkim : Damthang at 1833 m, 23. x. 1975, from Orchids (Orchidaceae), coll. P. K. Mondal.

Remarks : So far only the viviparous morphs occurring on *Hedychium coronarium* (Zingiberaceae) were known (Basu, 1967). In Sikkim both viviparae and sexuales have been found on *Elettaria cardamomum* (Zingiberaceae) and orchids (Orchidaceae). The present data suggest that the species is polyphagous and possibly breeds holocyclically at least in Sikkim.

Acknowledgements:– The authors are thankful to Indian Council of Agricultural Research, New Delhi for partially financing the work and to the Head of the Department of Zoology, University of Calcutta for laboratory facilities.

REFERENCES

BASU, A. N. (1964) New genera and species of aphids from the Darjeeling district, India (Homoptera: Aphididae). *J. Linn. Soc. (Zool.)*, **45**(305) : 233–243.

BASU, A. N. (1967) One new genus and seven new species of aphids from Darjeeling district, West Bengal (Homoptera: Aphididae). *Bull. Ent.*, **8**(2) : 1–15.

Entomon, 1978, *Vol*, 3, *No*. 1, *pp*. 111 *to* 113

A NEW SPECIES OF *MACROMYZUS* TAKAHASHI FROM WEST BENGAL

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(*Received 6 October 1977*)

A new species of aphid, *Macromyzus manoji* is described from West Bengal.

(*Key words :* **new species, aphid)**

While working on aphids from Nagaland some specimens of *Macromyzyus* Takahashi were collected. These on examination and comparison with literature were found to represent *Macromyzus woodwardiae* Takahashi.

Incidentally, it may be mentioned Ghosh, A. K. et al (1970, 1972) and Ghosh, M. R. et. al (1971) reported *M. woodwardiae* Takahashi from West Bengal. These on re-examination turned out as a new species and the same is described here. Thus the genus *Macromyzus* Takahashi presently contain three species, of which two are from Japan and one is from West Bengal.

Materials of the new species are in the collection of the Entomology Laboratory Department of Zoology, University of Calcutta.

Macromyzus manoji, sp. nov.

Apterous viviparous female (Fig. 1) : Body about 2.31—2.46 mm long with 1.32—1.39 mm as its maximum width. Head, brown to dark brown with spinules on both upper and under surfaces ; lateral frontal tubercles diverging, spinulose and median frontal prominence low but distinct ; dorsal cephalic hairs on strong sockets usually short and with blunt apices, ventral hairs also short with acuminate apices. Antennae 6-segmented, about 0.67–0.70 × the body ; basal two segments nearly concolorous with the head and with spinules ; flagellum pale brown with the apices of segments III, IV and V and bases of segments IV, V and VI slightly darker ; the very base of segment III, segments IV—VI imbricated and rest of the flagellum smooth ; flagellar hairs short with acuminate to bluntish apices, longest hair on segment III about 0.45–0.60 × the basal diameter of the segment ; segment III without secondary rhinaria ; processus terminalis about 2.40–4.60 × the base of segment VI ; primary rhinaria ciliated. Rostrum long, densely spinulose on all segments excepting the ultimate and the penulatimate ones ; u.r.s. about 1.30–1.40 × the 2nd segment of

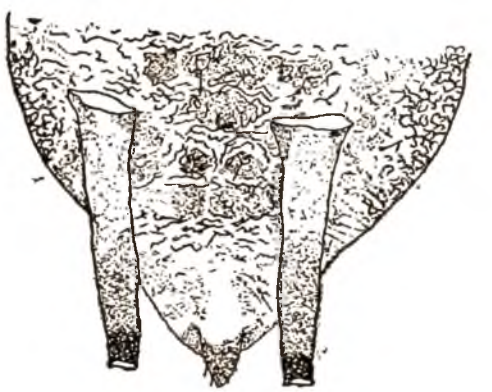

Fig. 1. *Macromyzus manoji*, sp. nov. : posterior portion of abdomen of apterous viviparous female.

hindtarsus and with 5–7 secondary hairs. Measothoracic furca with a very short stem. Thoracic tergites sclerotized and corrugated, these corrugations sometime appearing as spinules. In mature specimen prothorax with a brownish patch medially bearing a pair of hairs, each meso- and metathoracic tergite with a pair of hair bearing (?tubercle) patches spinally and a pair of marginal patches. Abdominal dorsum also sclerotized with spinal, pleural and marginal hair bearing (? tubercles) brown spiny patches on segments 1–6, the pleural and spinal ones fused to form distinct transverse bands specially on segments VII and VIII ; dorsal abdominal hairs stout, on strong sockets and with blunt apices ; longest hair on anterior tergites 0.90–1.0 ×the basal diameter of segment III, tergite 7 with 8 stout hairs and longest being about 1.0–1.20×the basal diameter of segment III, 8th tergite with 4 hairs, longest of these about 1.10–1.40 × the mentioned diameter. Siphunculi (Fig.1) about 0.24—0.28 ×the body, nearly cylindrical, dark brown with the apex pale, stout sparsely imbricated and with about 8–10 rows of isodiametrical cells near apex and without a distinct flange. Cauda short with a bulbous base and blunt apex with 4–6 hairs, about 0.26—0.27× siphunculi. Femora dark brown with basal 0.33–0.50 portion paler, with minute spinules which are denser near apex ; tibiae smooth, dark near base and apex, rest brown ; hairs on legs with acuminate apices ; tarsi without spinules. F.T.C. 4,4,3.

Alate viviparous female : Body about 3.19 mm long. Head sparsely spinulose dorsal cephalic hairs with blunt apices. Antennae brown with the basal two segments slightly darker ; segments I and II with spinules ; flagellum imbricated excepting major portion of segments III and IV which are smooth ; segment III with 28–31 and IV with 9–11 round, slightly protuberant secondary rhinaria which are not in a row. Ultimate rostral segment with 4 hairs. Abdominal dorsum pale and without reticulation or tubercles at the bases of the dorsal hairs. Tergite 7 with 6 long hairs, longest one being about 1.50×the basal diameter of antennal segment III ; longest hair on 8th tergite slightly longer than similar hair on 7th tergite. Femora and tibiae pale brown with the apices darker, wing venation normal but the veins slightly thicker and bordered brown. Other characters as in apterae viviparae.

Measurements of one aptera (holotype) in mm : Length of body 2.40 ; width 1.32 ; antenna 1.62 ; segments III : IV : V: VI 0.43:0. 27:0.24:(0.13+0.36) ; u.r.s. 0.15; h.t. 2 0.11; siphunculus 0.55; cauda 0.15.

Measurements of the alata in mm : Length of body 3.19; width 1.30; antenna 2.98; segments III: IV: V: VI 0.82:0.58: 0.51 : (0.16+0.73); u.r.s. 0.15; h.t. 2 0.10; siphunculus 0.78; cauda 0.19.

Holotype : Apterous viviparous ♀, INDIA: WEST BENGAL, Kalimpong, Kankebong, 15.ii. 1970 from unidentified plant, coll. M.R. Ghosh, **Paratypes :** one apterous viviparous ♀, collection data same as for the holotype ; two apterous viviparous ♀ ♀, INDIA: WEST BENGAL, Kalimpong, Algarha, 6.ii.1970 from *Disclesrea alata ;* one alate viviparous ♀, INDIA : WEST BENGAL, Lava, 30.vi. 1969 from *Clueilenthus varies*, coll. M.R. Ghosh.

Remarks : These specimens were reported by Ghosh, A.K. et al. (1970, 1972) and Ghosh, M.R. *et al.* (1971) as *Macromyzus woodwardiae* Takahashi. They reported through these papers apterae and alate viviparous female and also oviparae, though the last mentioned morph was reported with doubt as *M. woodwardiae* Takahashi. On re-examination it has been found that

these do not represent *woodwardiae* because of difference in shape and size of the siphunculi and also its colour. The siphunculi in *woodwardiae* are uniformly dark brown, gradually become narrower towards apex and possess a well developed flange but in the presently examined material the siphunculi are cylindrical, have a pale apex, and do not show any flange. Slight differences also lie at the morphometric level so a new species is erected with the re-examined material and with this new species the genus *Macromyzus* Takahashi is now known to contain 3 species, viz., *woodwardiae* and *polypodicola from* Japan and *manoji* from India.

The new species is named after the collector Dr. Manoj Ranjan Ghosh.

Acknowledgements:- The authors are thankful to the University Grants Commission, New Delhi for financing the project for working on the aphids of Manipur and Nagaland, the Head of the Department of Zoology, Calcutta University for Laboratory facilities, the Director of Agriculture, Government of Nagaland for extending necessary help during collection.

REFERENCES

GHOSH, A.K., M. R. GHOSH & D. N. RAYCHAUDHURI (1970) Studies on the Aphids (Homoptera: Aphididae) from Eastern India. II. Some new species and new records from North Bengal. *Orient. Insects*, **4**(2) : 199.

GHOSH, A.K., M. R. GHOSH, & D. N. RAYCHAUDHURI (1972) Studies on the Aphids (Homoptera: Aphididae) from Eastern India. XI. Description of hitherto unknown or newly recorded sexual morphs of some species from West Bengal. *Orient. Insects*, **6**(3) : 337.

GHOSH, M. R., A. K. GHOSH, & D.N. RAYCHAUDHURI (1971) Studies on the Aphids (Homoptera: Aphididae) from Eastern India. 6. New records from Sikkim. *Proc. zool. Soc. Calcutta*, 24 : 50.

TAKAHASHI, R. (1960) Four new genera of Aphidinae from Japan. *Kontyu*, **28** : 225-227.

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BRIEF COMMUNICATIONS

A NEW BRACONID PARASITE OF RICE-SKIPPER *PARNARA MATHIAS* FABRICIUS (LEPIDOPTERA : HESPERIIDAE)

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(Received 17 November 1977)

Larvae of the rice-skipper, *Parnara mathias* Fab. were recorded to be parasitized by *Charops biocolor*, *Apanteles* sp and *Clinocentrus indicus* to the extent of 76.3 per cent. *C. indicus* is an addition to the list of natural enemies recorded on this pest of rice.

(*Key words :* **Braconid parasite, rice skipper, *Parnara mathias***)

Rice crop in Punjab, is damaged by a number of pests, viz., plant hoppers, leaf hoppers, leaf folder, stem borers, rice hispa, grasshopper, rice-skipper, "Gundhi" bug, etc. Incidence of rice-skipper, *Parnara mathias* FABRICIUS is sporadic in Punjab. In certain years it occupies the position of serious pest and damages the crop in most of the intensive rice growing tracts of the State. The serious nature of infestation by this pest may be attributed to the injudicious application of pesticides, leading to disturbance of the natural balance.

During the crop season 1975, at Regional Rice Research Station, Kapurthala, Punjab, it was observed that the incidence of rice-skipper was on ascending side in the month of September. Some natural enemies, viz., *Charops bicolor* and *Apanteles* sp. were already recorded on this pest, during the past years. Hence, a study of the natural control of this pest, effected by its parasites was initiated.

Collection of rice-skipper larvae was made in the last week of September, 1975. In all 38 larvae were collected. These larvae were kept under constant observations in the laboratory. Only two larvae completed the development up to pupal stage. Seven out of the remaining 36 larvae neither completed their development nor gave rise to any parasite. These larvae died due to some

No. of parasitized larvae	Name of the parasite emerged	No. of adult parasite emerged	Per cent parasiti-zation
7	*Charops biocolor*	7	18.4
7	*Apanteles* sp.	216	18.4
15	*Clinocentrus* sp.	35	39.5
			76.3

unknown reasons. Parasites emerged from the remaining twenty-nine larvae.

The details of the parasites recorded and extent of parasitization in the larvae of *P. mathias* F. have been summerised in the table.

From the above data it may be inferred that 76.3 per cent larvae of the rice-skipper were recorded to be parasitized by the three parasites. The parasite *Clinocentrus* sp. is an addition to the list of natural enemies recorded on this pest of rice.

The parasite was identified as belonging to the genus *Clinocentrus* sp. (Hymenoptera : Braconidae) by the Commonwealth Institute of Entomology London. Later on the specimens were sent to Dr. V. K. GUPTA, Department of Zoology, University of Delhi, Delhl-7. The specimens have now been found to belong to a new species of this genus. The species has been named as *Clinocentrus indicus* and is being described by Dr. GUPTA.

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FIRST RECORD OF *NEOMYZUS CIRCUMFLEXUS* (BUCKTON) (HOMOPTERA : APHIDIDAE) ON YOUNG PINE SEEDLINGS (*PINUS KESIYA* ROYLE)

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(*Received 10 August 1977*)

Neomyzus circumflexus **(Buckton) has been recorded for the first time on a Gymnosperm plant,** *Pinus kesiya* **Royle in North-Eastern India. These aphids were seen to feed on young seedlings in pine plantation areas near Shillong (ca 1150m) in Meghalaya. Incidentally, this also forms the first record in India, of an Aphid species under the subfamily Aphidinae infesting** *Pinus* **sp.**

(*Key words :* *Neomyzus circumflexus*, *Pinus kesiya*, **young seedlings, Shillong**)

Neomyzus circumflexus (Buckton) is a well known polyphagous species with a wide cosmopolitan distribution. Hille Ris Lambers (1949) and Cottier (1953) have given detailed description of this species which has been recorded as a vector of about 30 viral diseases (Eastop, 1966).

Recently during an extensive, long term study on "Ecosystem function of Pine forests of Meghalaya, North-Eastern India," one of us (MVR) has observed infestation on young seedlings of pine (*Pinus kesiya* Royle) by aphids, which appeared somewhat different from the other two species viz. *Cinara attrotibialis* David and Raja Singh and *Eulachnus thunbergii* Wilson normally associated with this pine. These aphids were observed to infest seedlings, aged two months old. This infestation began from the month of July, 1976 and data obtained by regular weekly collections revealed their abundance as a definite peak during November. These colonies revealed apterous and alate, viviparous females besides nymphs at all stages of development. This also places on record for the first time an aphid genus and species of the subfamily Aphidinae infesting a member of *Pinus*.

Another interesting observation was that *Neomyzys circumflexus* (Buckton) which appeared on the young pine seedlings during July (seeds being sown in the last week of May), kept increasing till November and there was a sharp decline in their number from December onwards. However, from October when the temperature gradually falls, *Eulachnus thunbergii* Wilson appeared on the same plantationfeeding on needles. As winter approaches further, *Cinara attrotibialis* David and Raja Singh started infesting the same plantation feeding on the stems. At a certain period, all three species were seen together on the same plants. The last two species have been known to infest pines growing in different areas of North-Eastern India.

Acknowledgements:— The authors are grateful to Professors Dr. R. George Michael and Dr. P. S. Ramakrishnan of the School of Life Sciences, N. E. H. U. and to the Director, Zoological Survey of India for providing the necessary facilities. One of us (MVR) is grateful to N. E. H. U. for a fellowship during the tenure of which this work was done.

REFERENCES

COTTIER, W. (1953) Aphids of New Zealand. *Bull. N.Z. Dep. Scient. ind. Res.*, **106.**

EASTOP, V. F. (1966) A taxonomic study of Australian Aphidoidae (Homoptera). *Aust. J. Zool.*, **14 :** 399–592.

HILLE RIS LAMBERS, D. (1949) Contribution to a monograph of the Aphididae of Europe.IV. *Temminckia*, **8 :** 182–323.

RAYCHOUDHURI, D. N. (1973) *Taxonomy of the aphids of Eastern Himalayas.* PL 480 Project Technical Report, Dept. Zool. Univ. Calcutta, 1–107.

Statement of ownership and other particulars about ENTOMON

Form IV, Rule 8 of the Registration of Newspapers (Central) Rules, 1956)

1.	Place of publication :	Trivandrum
2.	Periodicity of publication :	30th June and 31st December
3.	Printer's name, nationality and address :	V. K. Kesava Prabhu, Indian, Department of Zoology, University of Kerala, Kariavattom, Trivandrum 695581
4.	Publisher's name, nationality and address :	—Do—
5.	Editor's name, nationality and address :	—Do—
6.	Name and address of individual who owns the newspaper :	Association for Advancement of Entomology, Department of Zoology, University of Kerala, Kariavattom, Trivandrum 695581

I, V. K. Kesava Prabhu, hereby declare that the particulars given above are true to the best of my knowledge and belief.

(Sd.)
Dr. V. K. Kesava Prabhu
Publisher, *Entomon*

Trivandrum
June 30, 1978

Entomon, 1978, *Vol.* 3, *No.* 1, *pp.* 119 *to* 121

FREQUENCY DIFFERENCES IN THE SEASONAL ABUNDANCE OF THE POLYMORPHIC MEMBRACID, *TRICENTRUS PILOSUS* ANANTHASUBRAMANIAN AND ANANTHAKRISHNAN (HOMOPTERA : INSECTA)

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(*Received 23 August 1977*)

The frequency differences in the occurrence of an oligotrophic, polymorphic membracid species, *Tricentrus pilosus*, on its two host plants, *Thespesia populnea* and *Ficus bengalensis*, are presented. The possible factors accounting for the differences in the abundance of the various morphs of this species on its host plants are discussed.

(*Key words :* **Frequency differences, polymorphic membracid,** *Tricentrus pilosus*, *Ficus bengalensis*, *Thespesia populnea*)

Information regarding the existence of polymorphism in the membracid bugs is not available except for the observations of CAPENER (1962) in many species of African Oxyrhachinae and of ANANTHASUBRAMANIAN & ANANTHAKRISHNAN(1975)in a number of Indian species. More recently, YASMEEN & AHMAD (1976) have reported variation in the size and shape of the suprahumeral horns in some species of the genus *Tricentrus* STAL. Of particular interest in this connection is *Tricentrus pilosus* (a polymorphic species exhibiting different degrees of development of suprahumeral horns. An analysis of the percentage of occurrence of the different morphs of this species was reported earlier (ANANTHASUBRAMANIAN & ANANTHAKRISHNAN,1975). This oligotrophic species occurs on the slender free-hanging prop roots of *Ficus bengalensis* as also on the young leafy twigs of *Thespesia populnea*, building up in number during certan seasons of the year and exhibiting differences in the relative abundance of the different morphs. The present study aims at an analysis of the seasonal variations in the frequencies of occurrence of the different morphs of this on its two different hosts.

Adults of *Tricentrus pilosus* were collected by hand-picking at intervals of ten days for a period of one year (June 1976-May 1977) from the proproots of *Ficus* and the leafy twigs of *Thespesia* in the vicinity of Madras, each site of collection covering an approximate area of 75 sq m, maintaining separate records of collections from the two host plants, each sample of collection comprising the individuals taken from 20 twigs of *Thespesia* and twenty proproot tips of *Ficus*. The different morphs were separated in the laboratory and tabulated together with the data regarding temperature, relative humidity and rain fall during the period of investigation obtained from the Regional Meteorological Station.

A perusal of the Table indicates that *Tricentrus pilosus* appears to be absent on the proproots of *Ficus* in the months of July and August and this total absence is preceded by a steep decline in number from April to June, while on *Thespesia* the species

TABLE: Effect of temperature, relative humidity and rainfall on the differences in the seasonal fluctuations of the different morphs of *Tricentrus pilosus* on *Ficus* and *Thespesia*.

Months	On *Ficus*								On *Thespesia*								Temp in °C	% RH	Rain fall in mm
	Females					Males			Females					Males					
	Total number of individuals	With normal horns	With short horns	With aborted horns	With no horns	With short horns	With aborted horns	With no horns	Total number of individuals	With normal horns	With short horns	With aborted horns	With no horns	With short horns	With aborted horns	With no horns			
June	12	..	3	1	1	4	..	3	45	12	..	..	10	10	..	13	35.8	73	81.6
July	..	..	..	..	..	..	..	..	50	10	8	2	10	10	1	9	35.3	65	175.9
August	..	..	..	..	..	..	..	..	56	12	10	3	7	14	2	8	31.4	81	32.8
September	24	5	2	1	4	4	..	8	30	10	7	1	2	..	1	10	34.1	76	23.4
October	28	5	4	1	7	5	..	6	30	4	6	..	5	10	..	5	31.3	82	370.8
November	34	8	3	..	9	8	..	6	13	7	..	..	3	..	..	3	29.4	91	807.3
December	40	12	6	2	8	6	..	6	18	4	..	..	4	4	..	6	28.8	88	13.2
January	42	10	6	1	7	8	..	10	28	8	..	..	4	4	..	12	31.0	78	0.01
February	38	10	6	1	7	6	..	8	22	5	..	..	5	5	..	7	29.9	81	5.0
March	28	8	3	1	5	6	..	5	23	5	..	..	5	8	..	5	31.9	81	0.5
April	20	6	2	1	5	3	..	3	35	12	5	..	3	10	..	5	33.9	74	4.8
May	20	..	8	2	4	3	..	3	39	14	..	..	12	7	..	6	36.3	67	86.4

occurs throughout the year and its number reaches the climax in the months of June to August. The present study has also brought to light that males with aborted horns are rare and they are not encountered on *Thespesia* from October to May, whereas such forms are absent on the proproots of *Ficus* throughout the year ; males with reduced horns and males with no horns occur more or less in equal proportions ; during the months of May and June, females with normal horns disappear and those with short or reduced horns dominate on this host plant. On both host plants, females with normal horns appear in sizable proportions only when the population builds up in number.

The factors responsible for the abundance or scarcity of a particular species of membracid on one host plant never always appear to be the same for the seasonal fluctuations of the same species on a different species of host plant. In the present observations, for instance, high temperatures during June and July seem to have an indirect effect in bringing down the number of *Tricentrus pilosus* on *Ficus*, while the same factor seems to have no adverse effect on the same species on *Thespesia* as evident from the increase in their number. Heavy rainfall mechanically sweeps away the individuals that are directly exposed, and this obviously accounts for the sudden decline in the number of this species on *Thespesia* during November and December. Those on the proproots, however, are shielded from the detrimental effect of rain by the dense overlying foliage of the host plant.

Acknowledgements :—Grateful thanks are due to Professor T. N. ANANTHAKRISHNAN for constructive ciriticisms on the manuscript. Thanks are also due to the University Grants Commission, New Delhi, for the award of a research grant during the tenure of which part of this investigation was carried out.

REFERENCES

ANANTHASUBRAMANIAN, K. S. & T. N. ANANTHAKRISHNAN (1975). Taxonomic, biological and ecological studies on some Indian membracids (Insecta : Homoptera). Part I. *Rec. zool. Surv. India*, **68** : 161–272.

CAPENER, A. L. (1962) *The taxonomy of the African Membracidae. Part I. The Oxyrhachinae.* Republic of South Africa Department of Agricultural Sciences Entomology Memoirs, **6** : 1–164.

YASMEEN, N. & I. AHMAD (1976) New species of *Tricentrus* STAL. from Pakistan, Azad Kashmir and East Bengal with phylogenetic considerations. *Mushi*, **49** : 95–125.

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ANTENNAL OLIGOMERY IN THREE SPECIES OF RHYPAROCHROMINES (HETEROPTERA : LYGAEIDAE)

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(Received 5 December 1977)

Antennal oligomery is reported in three species of Rhyparochrominae viz., *Dieuches discoguttatus* (DIST.), *Methochus uniguttatus* THUN, and *Elasmolomus sordidus* (FABR) and it is found that abnormality occurs in only one antenna. The abnormal antenna is slightly smaller than the normal antenna, apart from slight colour variation other structures do not vary and abnormality occurs more commonly in the females then in the males.

(*Key words:* Antennal oligomery; Rhyparochrominae)

Most rhyparochromine species are ground dwelling among humus and litter, most of them are small and provided with cryptic colouration. Our present day knowledge of their biology and morphology is meagre. Several interesting cases of mimicry, antennal oligomery, ecological differentiation, food preferences as well as taxonomic relationship of these rhyparochromines need extensive investigation (SLATER, 1964). SIGMUND HAGVAR (1968) recorded a deformed antenna from a single specimen of *Drymus brunneus* SAHLB. Examination of an extensive field population of three species of Rhyparochrominae viz., *Dieuches discoguttatus* (DISTANT), *Metochus uniguttatus* THUNBERG and *Elasmolomus sordidus* (FABRICIUS) during 1975–77, revealed a few types of antennal oligomery. Regular field studies on the population fluctuation of these three species during this period indicated heavy build up of population during August-November and the population size was smaller during the rest of the year. For this study insects were mostly collected from Madras and Coimbatore (S.India) daily during their peak population (August November), using light trap adjacent to the fields and also hand picked from their natural habitat. In all specimens examined, the deformed antenna was invariably of one side only, either of the right or of the left. More often the left antenna was deformed but it was not statistically significant, however it was statistically significant that in all the three species examined such abnormalities occurred more frequently in the females than in the males (Table 1)

TABLE 1. Population characteristics of the species.

Species	Number of insects examined	Number of insects with deformed antenna	Ratio abnormality	Abnormality in relation to sex ratio Female : Male
D. discoguttatus	497	25	19:1	4:1
M. uniguttatus	327	11	29:1	8:1
E. sordidus	200	5	39:1	4:1

TABLE 2. Colour differentiation between normal and abnormal antennae.

Species	Normal	Abnormal
D. discoguttatus	First segment and terminal one-half of fourth segment brown to black, basal one half of fourth segment white, second and third segment yellowish brown to brown, distal tips black.	First and second segments similar to normal antenna, third segment dark brown to black throughout.
M. uniguttatus	All the four segments black throughout except the basal one-fourth of the fourth segment which is white to yellow.	All the three segments black throughout.
E. sordidus	Basal half of first segment dark brown, second and third segments (except terminals) yellowish brown, terminal half of first segment, apex of second, third and terminal one-half of fourth segment all dark borwn to black and basal one-half of fourth segment white.	First and second segments similar to normal antenna third segment dark brown to black throught.

TABLE 3. Relative length (in mm) of segments of normal and abnormal antennae of the three species (Range given in parantheses, average of ten normal adults and all abnormal variants).

Antennal segments	*D. discoguttatus*			*M. uniguttatus*			*E. sordidus*			
	N	T1	T2	N	T1	T2	N	T1	T2	T3
I	1.10 (1.00–1.20)	0.98 ..	1.16 (1.10–1.24)	1.24 (1.20–1.30)	1.24 (1.20–1.30)	1.20 (1.16–1.24)	0.86 (0.80–0.96)	0.84 (0.80–0.88)	0.78 ..	0.84 ..
II	2.04 (2.00–2.10)	2.20 ..	2.50 (2.40–2.64)	2.20 (2.14–2.30)	2.80 (2.50–3.00)	2.50 (2.40–2.60)	1.64 (1.50–1.76)	1.76 (1.68–1.80)	1.38 ..	1.65 ..
III	2.02 (1.90–2.08)	1.96 ..	2.80 (2.62–3.00)	2.10 (2.04–2.20)	2.92 (2.80–3.20)	3.70* (2.40–3.80)	1.58 (1.46–1.62)	1.80 (1.74–1.86)	.. ..	0.40* ..
IV	1.84 (1.76–2.06)	0.40* ..	.. ..	2.30 (2.20–2.40)	.. ..	.. ..	1.42 (1.38–1.48)	.. ..	.. ..	.. ..
Total	7.00 (6.66–7.44)	5.44 ..	6.46 (6.12–6.88)	7.84 (7.58–8.20)	6.96 (6.50–7.50)	7.40 (6.96–7.64)	5.50 (5.14–5.82)	4.40 (4.22–4.54)	2.16 ..	2.89 ..

N—Normal antenna

T_1 to T_8—Abnormal types

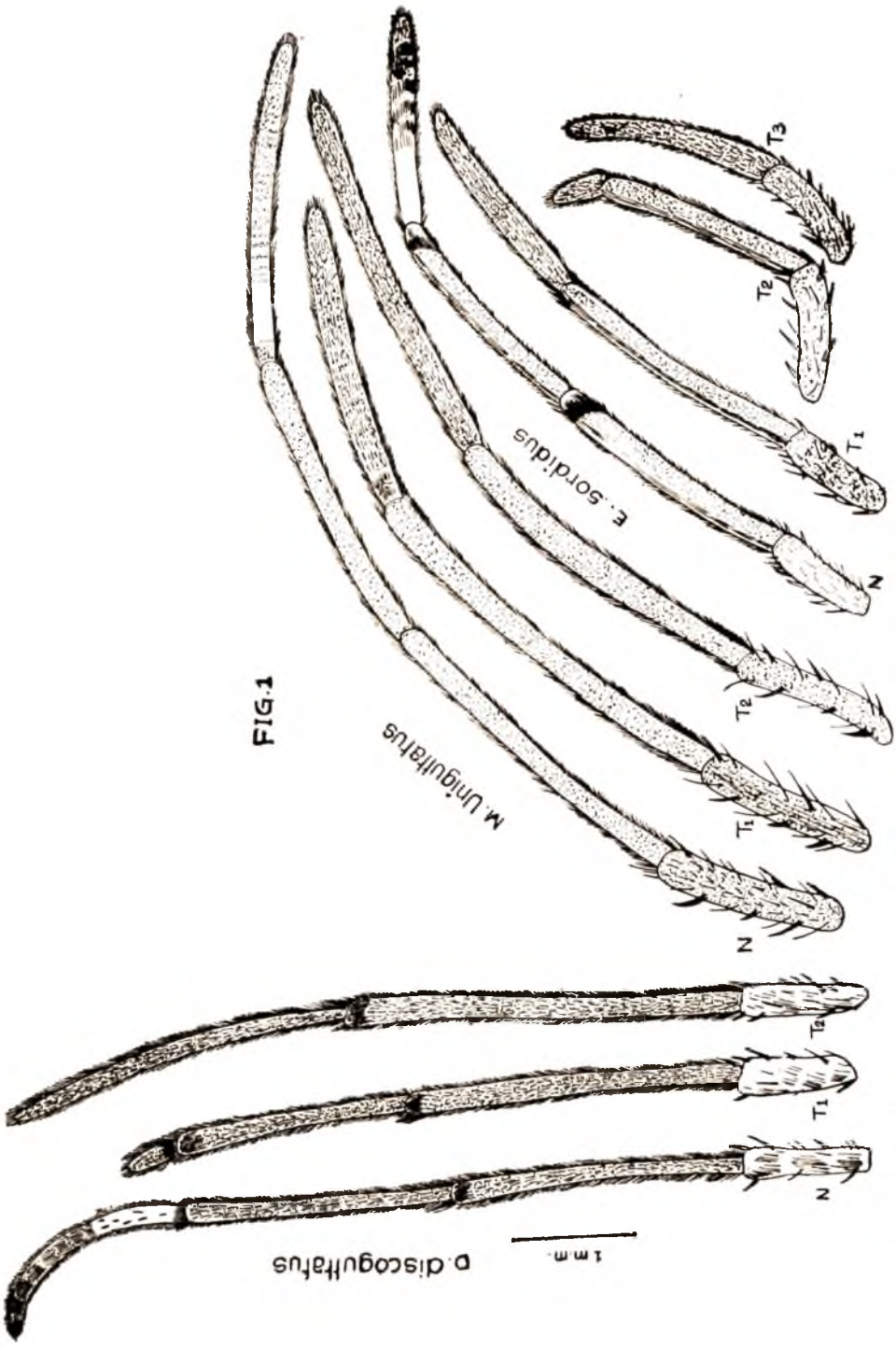

Fig. 1. Antennal malformation in three species of Rhyparochromines. N—Normal antenna; T_1–T_3—Types of abnormality.

Most of the deformed antennae examined had only three segments whereas the normal antenna has four. In a single specimen of *D. discoguttatus* and *E. sordidus* the deformed antenna had a very small appendix-like fourth segment while in another specimen of *E. sordidus* the abnormal antenna had only two segments. Analysis of the relative length of each segment of the three species (Table 2) revealed that the abnormal antenna was smaller than the normal antenna. In *E. sordidus* the abnormal antenna having only two segments was conspicuously smaller (2.16mm long) than its normal counterpart (5.5 mm long). However, the length of the first segment in the normal as well as abnormal antennae in all the three species did not vary significantly but the second and third segments of the abnormal antennae of *D. discoguttatus* and *M. uniguttatus* were slightly larger than the corresponding segments of the normal antennae. The slightly larger second and third segments of the abnormal antennae did not compensate fully the loss of fourth segments and hence the abnormal antenna was smaller then the normal antenna (Table 2). Morphological details of the antennae were carefully studied under microscope and there was no difference in the thickness or other structural details such as bristles and spines between the normal and the abnormal antennae, although there is variation in colouration, except in the firsts egment (Fig.1 & Table 3.)

Acknowledgement :—I gratefully acknowledge the valuable guidance of Dr. DAVID LIVINGSTONE, Reader in Entomology, University of Madras, P. G, Centre, Coimbatore and Dr. T. N. ANATHAKRISHNAN Director, Zoological Survey of India, Calcutta for his keen interest in my work.

REFERENCES

SLATER, J. A. (1964) Hemiptera (Heteroptera:) Lygaeidae. *South African Animal Life*, X : 15 – 228.

SIGMUND HAGVAR (1968) A deformed antenna in a bug and deformed hind legs of two beetles. *Norsk. ent. Tidsskr.*, **15** : 97–98.

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A NEW SCALE INSECT PEST OF CLOVE

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(Received 1 March 1978)

***Mycetaspis personata* (COMSTOCK) (Diaspididae : Homoptera) has been recorded as a new pest of clove (*Eugenia caryophyllata*) in Kerala, India.**

(*Key words :* **Scale insect pest,** *Mycetaspis personata*, **clove.**)

The masked scale *Mycetaspis personata* (COMSTOCK) (Diaspididae : Homoptera) was observed infesting leaves of clove (*Eugenia caryophyllata*) at Pappanamcode in Trivandrum District (Kerala State, India) in August 1977. This is the first record of the occurrence of this insect in India and as a pest of clove. *M. personata* is known as a polyphagous pest of fruit trees and palms in Egypt (LEPAGE & GIANNOTTI, 1943 ; EL MINSHAWY & OSMAN, 1974) and as a serious pest of mango (*Mangifera indica*), requiring often applied control, and studies have been made on its ecology and control (SALAMA, 1970 ,1972; SALAMA & SALEH, 1971, 1972).

The scale was observed infesting the undersurface of leaves of young clove plants (Fig.1). The infested leaves became discoloured and completely yellowish in due course. The attacked leaves finally dropped. The older leaves of the plant were infested more than the younger leaves.

The full grown scale (Fig.2) is dome-

Fig. 1. *M. personata* on clove leaf.

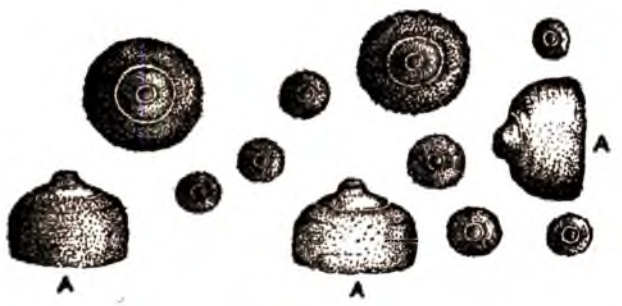

Fig. 2. *M. personata*. Scales marked 'A' are adults (side view).

shaped and greyish-brown with basal diameter of 1.24 mm and a height of 0.86 mm. The full-grown female insect is yellowish and sub-hemispherical with a length of 1.13 mm and a width of 0.95 mm. Eggs are laid under the scale packed in white meal.

The scale could be controlled by application of monocrotophos 0.05% emulsion.

Acknowledgement : Thanks are due to Dr. N. C. PANT, Director, Commonwealth Institute of Entomology, London, for the identification of the insect.

REFERENCES

EL MINSHAWY, A. M. & O. A. OSMAN (1974) Biological and ecological studies on the masked scale insect *M. personata* in Alexandria area (Coccoidea-Diaspididae). *Bull. Lab. Ent. agr. Filippo Silvestri*, **31** : 152–170.

LEPAGE, H. S. & O. GIANNOTTI (1943) Coccids infesting the Jaboticaba tree. *Biologico*, **9** (7) : 169–173.

SALAMA, H. S. (1970) Population dynamics of the scale insect *Mycetaspis personata* (COMSTOCK) in Egypt (Homoptera–Coccoidea) *Z. angew. Ent.*, **66** (1) : 42–46.

SALAMA, H. S. (1972) On the population density and bionomics of *Parlatoria blanchardi* (TARG) and *Mycetaspis personata* (COMSTOCK) (Homoptera–Coccidae). *Z. angew. Ent.*, **70** (4) : 403–407.

SALAMA, H. S. & M. R. SALEH (1971) Control of the scale insect *Mycetaspis personata* (COMSTOCK) (Homoptera—Coccoidae) in Egypt. *Bull. Ent. Soc. Egypt*, **5**: 155–158.

SALAMA, H. S. & M. R. SALEH (1972) Population of the scale insect *Mycetaspis personata* on different varieties of *Mangifera indica*. *Z. angew. Ent.*, **70** (3) : 328–332.

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BIOLOGY OF *LEMA LACORDAIREI* BALY (COLEOPTERA : CHRYSOMELIDAE : CRIOCERINAE) A PEST OF YAM *DIOSCOREA ALATA* IN KERALA

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(Received 1 March 1978)

Lema lacordairei BALY (Coleoptera : Chrysomelidae : Criocerinae) is a newly recorded pest of yam *Dioscorea alata*, an edible tuber of Kerala, India. Egg, larval and pupal periods last for 2.5, 6.5 and 8 days respectively. The grub is yellow, with thick fleshy abdomen and carries its excrements on its back. Pupation takes place in a cocoon made of a white frothy substance coming out of the mouth of the grub. Adult has shiny blue elytra and yellow body. Both adults and larvae damage the crop by defoliation.

(*Key words :* biology, *Lema lacordairei*, yam pest, *Dioscorea alata*)

Dioscorea alata, an edible tuber of Kerala (India) has been observed damaged, often seriously, by the adults and grubs of *Lema lacordairei*. Earlier records of chrysomelid beetles infesting yam (*Diascorea* sp.) are of *Galerucida bicolor* (HOPE) in South India (AYYAR, 1940) and of *Crioceris impressa* in Kashmir (SRIVASTAVA & BHAGAT 1966). The present paper embodies the results of the studies made on the biology of *L. lacordairei*, a new pest of *Diascorea alata* in Kerala.

Insects were reared in deep petri dishes on leaves of *D. alata*. The dishes were cleaned daily after making the observations and fresh leaves supplied. The quantity of food consumed by the adult/grub was determined in terms of the area of the leaf eaten each day, using a graph paper. The biological studies were made during May–October 1977.

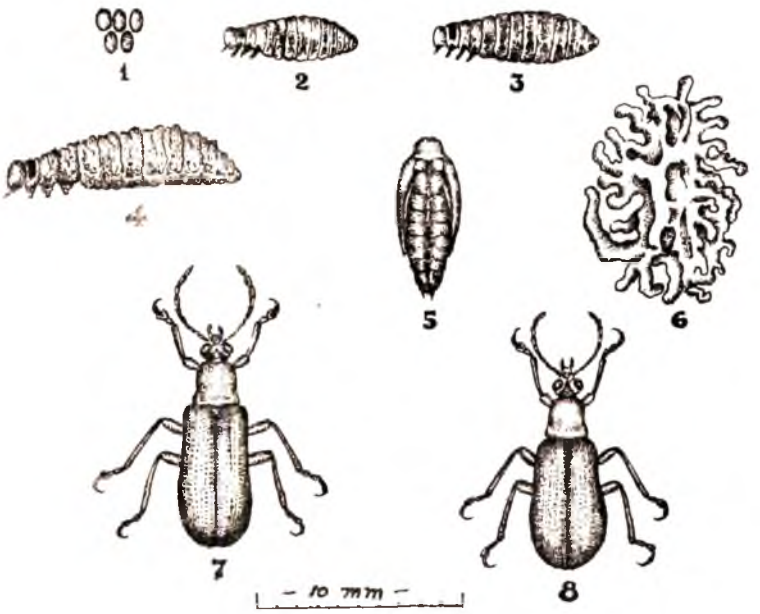
Life History

The beetles mate at night 2-3 days following emergence and oviposition commences 7 to 10 days after mating.

Oviposition: Eggs are laid in loose batches of 10 to 12 on the under surface of the leaves, on the vines and on the supports of the vines. After laying the first instalment of 10 to 14 eggs the egg-laying is discontinued for 10 to 15 days. Subsequently only 2 to 3 eggs are laid at a time till a female lays a total of 20 to 25 eggs during an oviposition period of 30 to 40 days.

The egg (Fig. 1) is yellowish, smooth and cylindrical measuring on an average 0.62 mm in length and 0.38 mm in width. The egg period ranges from 2 to 3 days. Upto 90 per cent of the eggs laid hatch in the laboratory.

The grub (Figs. 2, 3 & 4) has 3 instars with duration of 2.0, 2.0 and 2.5 days respectively. The length of larvae in the 1st, 2nd and 3rd instar are 2.9, 8.0 and 11.0 mm respectively; the corresponding head width being 0.88, 1.48, 2.16 mm. The grub has the characteristic criocerine features of a small head, narrow thorax and a disproportionately thick and fleshy abdomen. It has also the criocerine habit of concealing itself with coverings of its excrement carried dorsally. The grub is yellow in colour with brown head and black



Figs. 1–8. Life stages of *L. lacordairei*. 1. Eggs; 2–4. Grubs; 5. Pupa 6. Cocoon; 7. Adult male; 8. Adult female.

prothoracic shield and legs. The first instar larva feeds on the surface tissues of the underside of tender leaves; the later stages of the larva feeds on the whole lamina of the leaves and even on the tender vines. The final instar grub stops feeding after 2 to 3 days of its moulting and constructs a cocoon for pupation (Fig. 6). The cocoon is made of a white frothy material ejected out from the mouth of the grub. The thick froth dries to form a tough covering for the pupa. The cocoon is formed on the leaf, on the vine or on its support or in soil. Pre-pupal period lasts for 3 days.

The pupa (Fig. 5) is yellowish brown measuring 6.5 to 7 mm in length and 4 to 4.5 mm in width. The pupal period lasts for 7 to 9 days.

The adult (Figs. 7 & 8) on an overage measures 8 mm in length and 3 mm across the elytra. The elytra are shining blue in colour while the rest of the body is yellow. The adult beetle is active and takes to flight at the slightest disturbance. The male has a life span of 70 to 75 days and the female 90 to 95 days.

Damage caused (Fig. 9): The grub feeds on the tender leaves making irregular holes on them. Often the entire leaves are consumed leaving only the petioles. When all the leaves are exhausted, as it may happen in young plants, the grub eats up the petioles and parts of the tender vines. A grub during its 3 instars consumes on an average 1121 sq mm of leaf. The adult also causes damage by scraping the surface tissues of the leaves; it may however damage mature leaves as well. One adult during its life span consumes on an average 2848 sq mm of leaf lamina. Out of this the major portion is eaten during the first 15 days following its emergence. Thereafter it feeds very little and that too at intervals of 7 to 10 days only.

Fig 9 Yam leaf damaged by grub (left) and adult (middle) of *L. lacordairei* and healthy leaf (right).

Seasonal occurrence : The beetle starts appearing in the field with the onset of the pre-monsoon rains in May and remains active till October-November.

Acknowledgements :—Thanks are expressed to Dr. N. C. PANT, Director, Commonwealth Institute of Entomology, London for kindly arranging to identify the insect.

REFERENCES

AYYER, T. V. R. (1940) The bionomics of the yam beetle *Galerucida bicolor* (HOPE) a pest of cultivated yam in South India. *J. Bombay nat. Hist. Soc.*, **4** : 874–876.

SRIVASTAVA, J. B. & G. L. BHAGAT (1966) Studies on the biology of *Crioceris impressa* FABR. (Chrysomelidae : Coleoptera) a defoliator pest of *Dioscorea bulbifera* LINN. *Indian J. Ent.*, **28** : 435–437.

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EFFECT OF DIFFERENT INSECTICIDAL TREATMENTS ON THE CONTROL OF LITTLE-LEAF DISEASE AND THE FRUIT- AND THE SHOOT BORER OF BRINJAL

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(Received 10 August 1977)

An experiment was conducted to test the effectiveness of different insecticidal treatments against insect pests of brinjal and the pathogen of little-leaf disease. All the insecticidal treatments proved equally effective and significantly better than contol.

(*Key words* : **insecticidal treatments, brinjal, insect pests, pathogen, little-leaf disease)**

In an earlier communication it was reported that incidence of brinjal little-leaf disease and other insect pests could be reduced by the regular use of pesticides (SOHI *et al.*, 1974). Some additional information obtained during the study is reported herein.

The experiment was carried out with Pusa purple long variety of brinjal in a randomized block lay-out with 4 replications having a subplot size of 1/84 ha, using the following pesticide application schedules. S1- Phorate 10 g @ 1 kg ai/ha, first application at the time of transplanting and the second 30 days thereafter. S2–Phorate 10 g @ 1 kg ai/ha first application at the time of transplanting and the second 40 days thereafter. S3–Phorate 10 g @ 1 kg ai/ha at transplanting and 8 sprays of 0.07 per cent endosulfan at fortnightly intervals starting 30 days after transplanting. S4–Phorate 10g @ 1 kg ai/ha at transplanting and 8 sprays (sprays 1, 3, 5, 7 with 0.15 per cent carbaryl and 2, 4, 6, 8, with 0.05 per cent malathion) at fortnightly intervals starting 30 days after transplanting. S5–Phorate 10 g @ 1 kg ai/ha at the time of transplanting and 8 sprays of 0.15 per cent carbaryl at fortnightly intervals starting 30 days after transplanting. S6–Untreated control.

All the sprayings were done with high–volume nozzles. In all cases, except the control, a bare-root dip treatment (for 6 hours in 0.03 per cent dimethoate) was given before transplanting in order to check the root-knot nematode.

From the data (Table 1) it is evident that pesticide treatments proved equally effective and significantly better than control in respect of incidence of brinjal little-leaf disease, fruits damaged by the fruit borer, and loss in yield. The shoot-damage by the borer was significantly lower in S3 than in all the treatments except that in S5. Again, all the pesticide treatments proved better than control.

Untreated plants were attacked by *Amrasca biguttula biguttula* (ISHIDA). Its mean population varied from 1 to 8 nymphs per 4 leaves

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TABLE 1. Effectiveness of different schedules for the reduction of incidance of brinjal little-leaf disease and insect pests of brinjal.

Treatments	Mean percentage incidence			Mean percentage loss in yield	Mean yield of healthy fruits (kg/ha)
	Diseased plants	shoots bored	Damaged fruits		
S1	0.3 (5.01)a	6.5 (14.74)d	20.3 (26.78)a	19.3 (26.06)a	9744c
S2	0.2 (4.81)a	4.0 (11.57)c	17.9 (25.01)a	15.9 (23.49)a	16044b
S3	0.4 (5.50)a	1.1 (5.90)a	19.3 (26.09)a	19.4 (26.11)a	19656a
S4	0.2 (4.81)a	2.3 (8.74)b	17.9 (25.00)a	18.4 (25.42)a	19992a
S5	0.4 (5.23)a	1.6 (7.25)ab	18.3 (25.30)a	19.4 (26.11)a	21672a
Control	3.8 (11.97)b	16.7 (24.08)e	28.2 (32.09)b	30.8 (33.72)b	4368d

In column 2, the figures in parentheses are arc sin $\sqrt{p \pm 0.5}$ transformations, where p is the observed percentage incidence which is outside the parentheses.

In columns 3,4 & 5, the figures in parentheses are arc sin $\sqrt{\text{percentage}}$ and outside are back transformed per cent values.

Figures followed by same letter (s) are statistically non-significant.

(two upper and two middle leaves). Its population was high from July to September. The treated plants remained free from its attack except in S1 and S2 where a negligible population of nymphs was found in the end of September and October.

REFERENCES

SOHI, A. S., O. S. BINDRA & G. S. DEOL (1974) Studies on the control of brinjal little-leaf disease and insect pests of brinjal. *Indian J. Ent.*, **36** : 362–364.

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COMPARATIVE DIETARY EFFICIENCY OF COMMON SPICES AND OILSEEDS FOR THE LARVAL GROWTH OF *TRIBOLIUM CASTANEUM* HERBST (COLEOPTERA : TENEBRIONIDAE)

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(Received 17 August 1977)

Trials conducted on the relative dietary efficiency of seven common oilseeds and nine spices for *Tribolium castaneum* have shown that the order of preference for oilseeds was cottonseeds(*Gossypium* spp.), linseed (*Linum usittatisisnum*), groundnut (*Arachis hypogea*), taramira (*Eruca sativa*), toria (*Brassica napus*), mustard (*Brassica campestris*), sesamum (*Sesamum indicum*) and for the spices it was chilli (*Capsicum frutescens*), cardamon (*Ammomum subulatum*) and cinnamon (*Cinnamomum zeylanicum*). The oilseeds sesamum and the spices thymol (*Tracchyspemum ammi*), aniseed (*Foeniculum vulgare*), clove (*Syzygium aromaticum*), coriander (*Coriandrum sativum*), black pepper (*Peper nigrum*) and cumin-seed (*Cuminum cyminum*) did not prove suitable for the development of *T. castaneum*.

(*Key words* : **dietary efficiency, spices, oil seeds, growth**, *Tirbolium castaneum* larva)

T. castaneum is a serious pest of common flours of cereals and pulses such as wheat, maize, grams etc. and also attacks oilseeds, spices, dry fruits, dry milk etc. The development of this pest on only a few oilseeds and spices (URS & MOOKHERJEE, 1966; PUNJ, 1967) has been worked out. So nine common spices and seven oilseeds have been tested for their dietary efficiency for development of *T. castaneum*, the results of which are recorded here.

The oilseeds and spices were procured from the local market. They were crushed to have coarsely-ground preparations. Glass vials (5cm×2.5cm) contained two gm of food and an equal amount of food with 5% yeast. Two samples of wheat flour with and without 5% yeast were also kept as standard food. All samples were adequately sterilized and conditioned beforehand. To each of these vials were added 25 freshly hatched 1st instar larvae (0–24 hr old) and the vials were kept in an incubator at 30±1°C. All sets were replicated thrice. The development of the immature stages was watched till the emergence of the last adult in each tube. The growth index of the test insect was calculated by dividing the average percentage of adult emergence by the duration of larval and pupal period in respect of different foods including the standard food.

A careful study of the results of the above trials tabulated in Tables 1 and 2 indicates that the cottonseeds, groundnut and linseed with and without the addition of 5% yeast provide complete dietary requirements for the development of *Tribolium* larvae although the life cycle in all three foods is prolonged as compared to that on the standard food. The duration increases to about 5 times in the case of linseed. Whereas cottonseeds allow more than 70% adult emergence with and without the addition of 5% yeast, the percentage of emergence in the other two foods is relatively much lower, being 12% in the case of linseed and 4% in the case of groundnut. Taramira, mustard and toria,

TABLE 1. Growth index of *T. castaneum* on different oilseed diets.

Diet	Adult emergence %	Duration of larval & pupal period (days)	Growth index
Wheat (Standard)	80.00	27.00	2.97
Wheat+5% yeast	84.00	26.00	3.23
Cotton seeds	70.00	70.00	1.00
Cotton seeds+5% yeast	82.00	70.00	1.17
Taramira	—	—	—
Taramira+5% yeast	30.00	80.00	0.38
Groundnut	04.00	75.00	0.06
Groundnut+5% yeast	10.00	76.00	0.13
Linseed	12.00	110.00	0.11
Linseed+5% yeast	46.00	64.00	0.73
Mustard	—	—	—
Mustard+5% yeast	02.00	95.00	0.02
Toria	—	—	—
Toria+5% yeast	02.00	88.00	0.03
Sesamum	—	—	—
Sesamum+5% yeast	—	—	—

on the other hand, prove unsuitable for the development of the pest when these oilseeds are not mixed with 5% yeast. The addition of yeast in all these three oilseeds, however, permits limited development of the larvae although the percentage of emergence in the case of mustard and toria remains very low at 2%. In fact mustard and toria thus appear to be the least susceptable to the attack of the larvae even after the addition of 5% yeast. The susceptibility of taramira, however, significantly rises by a similar addition of 5% yeast. Compared to the present observations, PUNJ (1967), on the other hand, recorded cottonseeds, linseed and mustard seeds to be unsuitable for the development of *T. castaneum*. In the present trials, similar results have been achieved with regard to linseed, and mustard seeds but cottonseeds have proved suitable for the development. PUNJ (1967) recorded the emergence of a few adults on sesamum whereas no adult emerged from these seeds in the present study. URS & MOOKHERJEE (1966) also noted the completion of the life cycle of *T. castaneum* on the crushed sesamum seeds, although the duration of the developmental period was prolonged as compared to that on the groundnut seeds.

It has been noticed (Table 2), that the life cycle is completed only on two spices viz., *Capsicum frutescens* and *Ammomum subulatum*. The percentage of adult emergence in both the cases is, however, very

TABLE 2. Growth index of *T. castaneum* on different spices.

Diet	Adult emergence (%)	Duration of larval & pupal periods (days)	Growth index
Wheat (Standard)	80.00	27.00	2.97
Wheat+5%yeast	84.00	26.00	3.23
Chilli	8.00	61.00	0.13
Chilli+5% yeast	12.00	58.00	0.21
Cardamom	6.00	53.00	0.11
Cardamom+5% yeast	4.00	51.00	0.08
Thymol	—	—	—
Thymol+5% yeast	—	—	—
Cinnamon	—	—	—
Cinnamon+5% yeast	2.00	52.00	0.04
Aniseed	—	—	—
Aniseed+5% yeats	—	—	—
Clove	—	—	—
Clove+5% yeast	—	—	—
Coriander	—	—	—
Coriander5+% yeast	—	—	—
Black pepper	—	—	—
Black pepper +5% yeast	—	—	—
Cuminseed	—	—	—
Cumin seed+5% yeast	—	—	—

low even with the addition of 5% yeast. The remaining 7 spices proved completely unsuitable for the development of *T. castaneum*. But in the case of *Cinnamomum zeylanicum* the addition of yeast slightly increased the nutrition value as 2% of adults were able to complete their development. The only study on the nutritional suitability of spices is by PUNJ (1967) who tested 4 spices viz., thymol, coriander, aniseed, and turmeric and found all of them unsuitable for its development.

Acknowledgements :—The authors are thankful to Dr. G. P. SHARMA, Senior Professor and Head, Department of Zoology, Panjab University, Chandigarh, for providing necessary research facilities.

REFERENCES

PUNJ, G. K. (1967) Dietary efficiency of natural foods for the growth and development of *T. castaneum* HBST. and *Corcyra cephalonica* STAINT. *Bull. Grain Techno.*, **5** : 209–213.

URS, K. C. D. & P. B. MOOKHERJEE (1966) Effect of oilseeds food on the biology of *T. castaneum* HBST., *Trogoderma granarium* EVERTS and *Corcyra cephalonica* STAINT, and their susceptibility to Pyrethrins. *Ind. J. Ent.*, **28** : 234–240.

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SYMPOSIA

ALL INDIA SYMPOSIUM ON ENVIRONMENTAL BIOLOGY

An All India Symposium on Environmental Biology, jointly sponsored by the University Grants Commission and the University of Kerala was held in the Department of Zoology, University of Kerala on 27, 28 and 29 of December 1977. The main feature of the symposium was that it covered a large number of related fields such as entomology and ecology of pests, natural ecosystem, ecophysiology, behavioural biology, pollution and radiation biology and wild life biology. More than two hundred delegates from various parts of India participated in this symposium and 123 papers were presented.

A wide range of topics in Entomology such as environmental factors on reproduction, insects as biological control agents, mating, nest building and oviposition behaviour, irradiation and induced sterility, effects of insecticides on pests, integrated control and population dynamics were presented. More than forty papers were from the field of entomology, though many were presented in sessions other than Entomology and Ecology of pests.

Natural ecosystem and ecophysiology session of the proceedings included forty seven papers. These covered ecosystems such as Arabian sea, the sewage stabilization ponds, fresh water reservoirs, natural lakes, grasslands, forest land, etc.

The behavioural biology section proved to be an interesting one and the participants presented 19 papers. The stimulating papers and active discussions spread over to two sessions. To conclude the symposium as scheduled, a parallel session was arranged for the behavioural biologists.

The prominent and interesting papers presented in the session for ecology of pests were mainly from the fields of applied entomology, predatory nematodes, mites and pests on Teak plantations in Kerala.

Population and radiation biology and wild life biology formed the subject for the concluding session and 29 papers were presented. Apart from the impact of factory effluents, pesticides, fungicides etc. on natural ecosystems, an interesting paper or common allergens of Kerala was also presented which attracted considerable attention.

A deep concern over the fate of endangered species of wild animals was felt throughout the session on wild life biology. The participants unanimously passed a resolution to request the Government of India to reconsider the implementation of the Silent Valley project which would pose a grave threat to the existing balance of nature and destroy the remnant sylvan forest and its denizens.

It has been proposed to publish the proceedings of the symposium very shortly. For copies and other information people interested may contact the Convener, All India Symposium on Environmental Biology, Department of Zoology, University of Kerala, Kariavattom, Trivandrum 695581.

G. K. KARNAVAR

WORKSHOP ON POPULATION ECOLOGY OF INSECTS

An All India workshop on Population Ecology of Insects of Economic Importance was held in the Division of Entomology of the University of Agricultural Sciences, Bangalore, from January 18–20, 1978. In a densely populated country like India, where the population still registers a 2.5% annual growth and where a large segment of the population is living below the line of poverty, massive efforts are being made to boost up agricultural production. These efforts would suceed only when effective measures are available for protecting the crops from pests. Insects apparently are the most difficult of pests to tackle and much would have to be learnt about their ecology under tropical conditions in order to evolve strategies of management desirable from the agricultural, economic and public health point of view. The present symposium, which has attempted to bring together insect ecologists of this country is a welcome step in this direction.

About 50 scientists participated in the workshop and discussed papers on a wide range of topics. Population dynamics in relation to abiotic factors and certain biotic factors received greatest attention covering several species of pests attacking a variety of crop plants, insects of medical and veterinary importance and others. Interesting papers were also presented on sampling, effects of crowding, life-table construction and regional variation in the incidence of pests. Some of the contributions dealt with insect pest complexes of a major crop and others considered in detail the causes of spread of a group of pest species attacking several crops in India during the course of a short period. There were also a sizeable number of papers concerned with biology and ecology of parasites and predators clarifying aspects of host–parasite and predator–prey relations. The need for studies which would contribute to the development of population models of major pests was stressed by the participants. Altogether 54 papers were presented in the workshop in three sessions. There were 35 papers in Agricultural Entomology, six in Veterinary and Medical Entomology and 13 in insect parasites and predators and other related aspects. In spite of the fact that a large number of insect pests were known to attack forest plantations affecting the economy of the country there were no papers on forest entomology.

The workshop was organised by PROF. G. K. VEERESH in keeping with the resolution passed in the Second Oriental Entomology Symposium held at Madras during March, 1977. It is learnt that the proceedings of the workshop will be published.

N. R. PRABHOO

WORKSHOP ON SOIL MICROARTHROPODS

The active study of soil animals in general and soil insects in particular, from the ecological point of view, was undertaken only since the second world war and that too mostly in the temperate countries of the west. The tropics still remain virtually unexplored but for some isolated studies in the Southeast Asia and Africa. There have also been few attempts made in India to study the soil condition and also with the richness of the soil fauna, one would feel that much remains to be done in this country. However at the moment there is a real dearth of trained personnel to undertake such studies.

In this context the Workshop on Soil microarthropods organized by the Zoological Survey of India at Calcutta from March 2–4, 1978 is to be commended. There were about 30 participants drawn from Zoological Survey, its regional stations and from a few Universities.

Inaugurating the Workshop DR. S. K. MUKHERJEE, the Vice-Chancellor of the Calcutta University said that although chemists were mainly associated with the study of the soil for a long time in the past, there was no doubt about the role played by the soil animals in the complex process of soil development. A number of organisms are known to produce secretions of proteinaceous nature capable of binding the soil particles and thus producing soil aggregates. The contribution of soil animals to the maintenance of soil porocity is also well known. He stressed the need for a multidisciplinary approach for the study of soil involving biologists, chemists and other physical scientists.

Addressing the participants DR. T. N. ANANTHAKRISHNAN, Director of the Zoological Survey of India, focused the attention to the complexity of life in the soil and indicated the importance of soil arthropods in the decomposition of organic matter. He also felt that in view of the key position of the microarthropods in the soil biota, their study in great detail should be undertaken earnestly. Dr. S.K. MITRA then spoke about the plan of work undertaken by the Survey to study the microarthropods in the soil of the major crop types. The results of these studies are expected to help understand the specific role of microarthropods in the soil subsystem. The presentation of papers started with a discussion of sampling and extraction techniques in which three participants critically reviewed a considerable body of information available on this subject. This was helpful in knowing the criteria to be adopted in choosing the unit size, sample size, the location of sample units in the field, the sampling depth and frequency of sampling. There was also a fruitful discussion on the methods of extraction and it was felt that by and large a modified version of the Berlese–Tullgren funnel extractor would be suitable for extracting microarthropods from loamy soil with moderate to large quantity of organic matter. A few contributions showed how distribution and abundance of individual groups like Collembola, mites and Symphyla could be related to certain soil factors so that the above groups could serve as indicator organisms. There were also papers of a more general nature touching microarthopods as a whole. The importance of termites in tropical ecosystems was stressed and it was also felt that studies on soil fauna would become complete only when the soil inhabiting pests like white grubs and root aphids were not excluded from the purview of the investigation. The presentation of the papers was followed by a demonstration of the working of a few types of extraction apparatus and the workshop concluded with a field trip.

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BOOK REVIEW

INDIAN CHELONETHI, by V. A. MURTHY and T. N. ANANTHAKRISHNAN, *Oriental Insects* Monograph No. 4, University of Delhi, 1977, 210 pp including 51 figures.

Chelonethi or the Pseudoscorpions are one of the several groups of microarthropods commonly inhabiting the soil and litter and bark of trees. Some of them are also known to live in bird nests and chicken houses. In general they are found to be predatory, feeding on small insects, in particular the Collembola, living in the litter and on the bark. Knowledge of the ecology and biology of this group would therefore add much to our understanding of the soil ecosystem. Fruitful research along these lines is however possible only if there exists a good and reliable taxonomic foundation. V. A. MURTHY and T. N. ANANTHAKRISHNAN have attempted to provide this for the benefit of the soil biologists through their studies on the pseudoscropions.

The Monograph, *Indian Chelonethi*, fourth in the series published by the Association for the study of Oriental Insects, is a revisionary work dealing with 98 species and 48 genera. Of these 52 species and three genera are new to science. Our knowledge of the Indian Chelonethi has thus increased two fold with the publication of this monograph. In this work the authors have reviewed briefly the taxonomic information available on this group giving emphasis on the pseudoscorpions of the Indian subregion. This is followed by a good account of the methods of collection, preservation and preparation of the animals for the taxonomic studies. A beginner would usually find it difficult to follow a taxonomic account unless he is familiar with the terminology used in the description of the taxa. The section of Taxonomic criteria gives a lucid and illustrated account of the taxonomic features of the pseudoscorpions. The largest section of this work comprises an account of the system in which are given keys to suborders, families genera and species. The keys are simple and easy to follow. Besides the characters mentioned in the keys, short accounts of the diagnostic features of the genera are also given. The new taxa dealt with in this work are described in detail and are supported by good illustrations. The authors make a few general remarks on the inadequacies of taxonomic criteria used in separating species and higher categories of pseudoscorpions, in the small and final section of the monograph. There is also an exhaustive bibliography of about 190 references.

The monograph would thus prove handy to the specialist and would be of considerable aid to the young workers on this group. Perhaps it would have been worthwhile to provide short taxonomic accounts of species which have already been described from India earlier eventhough they have figured in the keys. Further nothing has been mentioned about the distribution of most of the species. This information would have enabled the student to understand the zoogeographic relationship of the Indian forms. Taxonomists should take special care to see that the names of the taxa are properly spelt. Unfortunately one would feel that such care has not been bestowed while bringing out this monograph. Similarly although in the preface it is mentioned that the monograph is a compilation of 98 species distributed in 48 genera one does not find that all of them are listed. I have, however, no doubt that the monograph will be welcomed by all students of soil zoology in India in particular and tropics in general.

N. R. PRABHOO

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Books: NAYAR, K.K. (1973) *Elements in Insect Endocrinology*, Prentice Hall, India, 56pp. *Chapter in a book compiled and edited*: GILBERT, L. I. & D. S. KING (1973) Physiology of growth and development: Endocrine aspects, 249–370, *in: The Physiology of Insecta*, Vol. **1**, 2nd ed. (ed. ROCKSTEIN, M.), Academic Press, New York & London.

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Reg. No. R. N. 29386 / 76

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Printed by V. K. K. Prabhu at St. Joseph's Press,
Trivandrum for the Association for Advancement of Entomology.